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Demonstration of Ice-Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

Final Report on Project AR-F-318 for FY05

Vicki L. Van Blaricum, Vincent F. Hock, Timothy K. Perkins,
James Bushman, and Bopinder Phull

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Abstract: The anodes for conventional cathodic protection (CP) systems used inside water storage tanks are often damaged by ice during cold weather. The CP system described in this report uses ceramic-coated wire anodes and a floating support system to keep the anodes submerged beneath surface ice in the tank. Demonstration systems were installed in two elevated water storage tanks at Fort Drum, NY. System performance is monitored using the existing supervisory control and data acquisition (SCADA) system at Fort Drum. This report describes the ice-free CP system design, implementation, and performance during Fiscal Year 2005.

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Introduction

This demonstration was performed for the Office of the Secretary of Defense (OSD) under Department of Defense (DoD) Corrosion Control and Prevention Project AR-F-318, “Ice-free Cathodic Protection Systems for Water Storage Tanks at Fort Drum”; Military Interdepartmental Purchase Requests MIPR5CCERB1011 and MIPR5C6AG3CPC1, dated 15 December 2005. The proponent was the U.S. Army Office of the Assistant Chief of Staff for Installation Management (ACSIM), and the stakeholder was the U.S. Army Installation Management Command (IMCOM). The technical monitors were Daniel J. Dunmire (OUSD(AT&L)Corrosion), Paul M. Volkman (IMPW-E), and David N. Purcell (DAIM-FDF).

The work was performed by the Engineering and Materials Branch (CEERD-CF-M) of the Facilities Division (CF), U. S. Army Engineer Research and Development Center – Construction Engineering Research Laboratory (ERDC-CERL), Champaign, IL. The ERDC-CERL project managers were Ms. Vicki Van Blaricum and Mr. Vincent Hock. Significant portions of this work were performed by Mr. James Bushman and Dr. Bopinder Phull of Bushman & Associates, Inc., Medina, OH. The contributions of subcontractors Jonathan Freeman, Freeman Industries; Katy Craig, Terry Englehardt, and Gary Caruso and staff, Hach Corporation; and Steve Jacovich and Bill Burch, Bristol Babcock Corporation, are also acknowledged.

The following Fort Drum personnel are gratefully acknowledged for their support and assistance in this project:

- Mr. Tom Ferguson, Chief, Operations and Maintenance Division, Directorate of Public Works (DPW)
- Mr. Ed Rohr, Chief, Utilities Branch, DPW
- Mr. John Field, Telemetry Systems Engineer, DPW
- Mr. Frank Coburn, Exterior Piping and Water Treatment Plant Foreman, DPW.

At the time this report was published, the Chief of the ERDC-CERL Materials and Structures Branch was Vicki L. Van Blaricum (CEERD-CF-M), the Chief of the Facilities Division was L. Michael Golish, (CEERD-CF),

and the Technical Director for Installations was Martin J. Savoie (CEERD-CV-ZT). The Deputy Director of ERDC-CERL was Dr. Kirankumar Topurdurti and the Director was Dr. Ilker Adiguzel.

COL Gary E. Johnston was the Commander and Executive Director of ERDC, and Dr. James R. Houston was the Director.

Executive Summary

This project demonstrated the use of an impressed current cathodic protection (CP) corrosion prevention system that is designed for use in elevated water storage tanks in locations with cold winters. Conventional CP systems in cold locations are often prematurely damaged or destroyed by the formation of ice inside the tank. The CP system demonstrated here is designed to prevent ice formation on system anodes and wiring by anchoring them to a tethered flotation system that stays under water. This design also prevents system components from becoming entangled and damaged by the floating ice layer that typically forms on the water's surface.

Ice-free CP systems were designed and installed in two elevated water storage tanks at Fort Drum, NY. They were interfaced with Fort Drum's existing supervisory control and data acquisition (SCADA) system for performance monitoring, including tank-to-water potentials, rectifier outputs, corrosion rates with and without CP, and selected water quality parameters.

This report documents the CP system design, installation, and first 6 months of operation data. Preliminary data indicate that the systems are providing continuous cathodic protection to the interior surfaces of the tanks. Additional monitoring will be conducted and reported at the conclusion of this multi-year project.

Unit Conversion Factors

Multiply	By	To Obtain
degrees Fahrenheit	$(F-32)/1.8$	degrees Celsius
feet	0.3048	meters
gallons (U.S. liquid)	3.785412 E-03	cubic meters
inches	0.0254	meters
mils	0.0254	millimeters
square feet	0.09290304	square meters

1 Background

Elevated steel potable water storage tanks and their associated piping have been identified as critical infrastructure at military installations. Soldiers, their families, and civilian employees depend on them to provide a safe and reliable source of water for drinking, bathing, washing, and cooking. The tanks also provide water storage capacity and pressure to the distribution system for firefighting.

Water storage tanks should have a service life of 50 to 75 years. Interior corrosion of the storage tank can result in safety hazards, shortened service life, and poor water quality for consumers.

It is standard practice to install impressed current cathodic protection (CP) systems inside water storage tanks to prevent corrosion from occurring. The CP anodes are typically suspended from the roof of the tank with wires and cables such that they are submerged in the water. Such systems are often prematurely damaged or destroyed when surface ice forms in the tank in very cold environments. For example, the CP system in one of Fort Drum's potable water storage tanks was completely destroyed in 2000 due to ice damage after only a few years of service. This is a persistent problem at DoD installations with water storage tanks located in areas with cold winters. The CP system must be repaired or replaced immediately to prevent corrosion damage inside the tank.

Older water tank CP systems used heavy (approximately 40 pounds) silicon-iron or graphite anodes. Such systems were vulnerable to failure not only due to ice, but also due to the weight of the suspended anodes pulling on the wire and electrical connections. Ceramic-coated anodes have been used as a lightweight alternative to the silicon-iron and graphite anodes in recent years. These anodes are typically made by depositing mixed metal oxides onto titanium substrates including rods, wire, and discs. The ceramic-coated anode eliminates the problems caused by anode weight. For example, the anode rods only weigh 4 ounces each. When they are suspended from the roof of the tank, however, the anodes, cables, and wiring are still susceptible to ice damage.

Protective coatings alone are insufficient to prevent corrosion inside water storage tanks; in fact, accelerated corrosion can take place at defects in the coating if there is not a properly functioning CP system to prevent it.

Industry has created an innovative CP system design for water storage tanks that incorporates the ceramic-coated anode and overcomes the problems of anode fragility and ice accumulation, yet still meets the requirement of submerging the anode in the water such that it does not make electrical contact with the tank.

Ice-free CP systems were designed and installed in two (2) one-million-gallon elevated potable water storage tanks at Fort Drum during this project: one 20 year old tank and one newly constructed tank. Fort Drum's existing SCADA system was modified to monitor the performance of the new CP systems. Corrosion rate and water quality sensors were installed at various locations to help quantify the benefits of CP and provide monitoring at key locations in the distribution system.

The project management plan is included in Appendix A.

2 Lessons Learned

The project team learned several valuable lessons that will be useful to others wishing to implement ice-free CP systems and monitoring. It is especially important to pay attention to these things when: (1) multiple organizations, contractors, and/or suppliers are involved; (2) the CP installation is dependent upon the correct and timely execution of other peoples' work (such as during a new construction or recoating project); (3) the tank has a non-standard or unusual design; and/or (4) intermittent or partial project funding makes timely and coordinated execution difficult.

2.1 Tank preparation

Prior to beginning site work, it is important to ensure that:

1. Physical inspection is performed to confirm the current condition and design of the tank;
2. The tank has appropriate access hatches and that they are adequately sized and positioned to ensure worker safety;
3. The hatches are free of obstructions or other problems that could make it difficult or impossible to introduce the CP system components into the tank;
4. The tank's interior is dry and clean to avoid slipping hazards.

2.2 Weather and scheduling

Installation of ice-free CP systems during very cold weather should be avoided if possible. The primary concern is the safety of workers, as the interior tank surfaces can become icy and slippery.

One of the ice-free CP system configurations described in this report requires on-site assembly of the PVC pipes for the anode flotation system. Pipe cement is temperature-sensitive and will not set properly if the assembly is done in a cold environment. Thus, this configuration should not be used if the temperature at the time of assembly is below the cement manufacturer's recommended limit. If cold weather installation cannot be avoided, a design must be used that does not require on-site joining of PVC plastic pipes. Both designs are discussed in this report.

Installation of the ice-free CP system should be scheduled at a time when the tank can be removed from service for 1 to 2 weeks without adversely impacting the operation of the water distribution system. Two to five days should be allowed for the installation of the system. Time is required to empty, clean, and dry the tank before installation begins. Time is also required after installation to clean, sanitize and fill the tank.

2.3 SCADA

Installations with SCADA or other data acquisition systems may wish to use the system to monitor the CP system's performance. If this is to be done, it is critical to coordinate with SCADA system experts (contractors and/or installation personnel) as early in the process as possible. Specifically, the following must be addressed:

1. Coordinate physical and network limitations for new SCADA components to determine how and where components are going to be connected;
2. What signals will be produced;
3. Ensure new signals are compatible with the existing SCADA system. If not, determine up-front what kinds of adapters or converters are needed;
4. What the end results (such as data displays) are to look like;
5. How SCADA system programming will translate "raw" readings into meaningful data for the end user. It is very easy to make mistakes in this area. Mistakes in programming will cause the data to be interpreted and displayed incorrectly, and the engineering staff will be making decisions based on erroneous information;
6. Installing surge (or other necessary) protection for SCADA system components.

3 Technical Investigation

3.1 Problem statement

Interior corrosion of elevated water storage tanks can result in safety hazards, shortened service life, and poor water quality for consumers. It is standard practice to apply a protective coating to the tank interior, and to install a cathodic protection (CP) system to prevent corrosion at defects in the coating. Conventional CP systems installed in elevated water storage tanks in cold climates are frequently damaged and rendered inoperable by the ice that forms inside the tank. Industry has developed new CP system configurations that are designed to avoid this problem, and their effectiveness in a field application needs to be verified.

3.2 Approach

The contractor developed work, communications, and data collection plans as well as a safety manual. These documents are included in Appendix B.

Two 1,000,000 gallon hydropillar-style elevated water storage tanks at Fort Drum were selected for installation of the ice-free CP system. One tank (called Tank 3) was approximately 20 years old at the time of installation (Figure 1) and had areas of interior coating damage and corrosion (Figure 2).¹ The other tank (called Tank 1) was brand new; in fact, construction was still in progress at the beginning of this project (Figure 3).

It was decided to utilize Fort Drum's existing Bristol Babcock SCADA system to monitor the performance of the CP system and to monitor corrosion rates and water quality in the tanks and at other critical locations in the water distribution system. Comparison of the corrosion rate in protected and unprotected areas allows the benefits of the CP system to be quantified.

¹ All figures are presented in order following the Conclusions chapter.

3.3 CP system design

The ice-free impressed current cathodic protection (ICCP) system was designed using the following summarized protection requirements. Details are provided in Appendix C and Appendix D.

1. Design current density:
 - a. 2.5 mA/ft² for bare steel;
 - b. Coating damage assumed to less than 5% initially;
 - c. With final condition at the end of 20 years less than 25%.
2. Protection potential:
 - a. Minus 0.85 volts (vs. copper/copper sulfate reference electrode) per NACE Standard RP-01-69;
 - b. Free of IR Drop.

Two different ice-free CP system configurations were considered for this project. Each system utilized commercially available, ceramic-coated, mixed-metal-oxide wire anodes spirally-wrapped around a tethered flotation “buoy”. The difference between the candidate system configurations was in the design of the buoy.

3.3.1 Initial design

In the initial design (Figure 4), an octagonal-shaped buoy was to be constructed on-site inside the tank from 4-inch diameter Schedule 40 PVC pressure pipe sections. The sections could not be pre-assembled because the finished buoy would have been much too large to insert through the tank hatch. The buoy was then to be tethered with polyester ropes to the bottom of the “dry riser” in the center of the tank. The CP systems were originally scheduled to be installed during September. However, due to delays in the construction of the new Tank #1, installation was necessary during cold weather. The PVC cement for joining pipes would not set properly in the cold weather conditions, so the following alternative design was used.

3.3.2 Final design for installation during cold weather

An alternative design was created in which 4-inch diameter Schedule 40 PVC pressure pipes form the “spokes” of an octagonal umbrella-like support structure (Figure 5 through Figure 9). These anode support arms are attached to the dry riser via hinged connectors. Polyester marine rope

forms the outer hoop of the support structure, and the anode wire is wrapped around the rope. PVC legs at each corner of the octagon and oriented downward from the plane of the hoop prevent contact between the anode and the tank walls. Four commercial fishing net floats are attached at the far end of each anode support arm to prevent the hoop from sinking.

The positive lead wires (attached to the anode wire on two diametrically opposite sides and connections water-proofed) are also spirally wound around the buoy and terminated to the outside through a tank-entrance pressure fitting. A lead wire from a copper/copper-sulfate reference electrode permanently mounted on the hoop leg is also terminated to the outside via this fitting. The negative lead wire is Thermite® welded to the steel tank access tube ladder strut, coated with epoxy, and also terminated to the outside through this pressure fitting.

Each CP system is powered by an automatic IR drop-free potential-controlled rectifier with a maximum DC output of 30 Volts and 20 Amperes. The positive lead wires from the anode and negative lead wire from the tank are connected to this rectifier.

This CP system design does not require on-site assembly of PVC pipe sections, thus it is possible to install it during cold weather. CP systems were constructed according to this design and were installed in both Tank 1 and Tank 3. Figure 10 through Figure 16 are photos taken during the CP system installation.

3.4 Performance monitoring system

The existing Fort Drum Supervisory Control and Data Acquisition (SCADA) system was augmented with additional sensors and programmed to monitor tank tank-to-water potentials, CP rectifier outputs, water system corrosion rates with and without CP, and selected water quality parameters. The SCADA system interrogates all of the sensors described below at 15 minute intervals and transmits the data to a control room located at the DPW office.

3.4.1 CP system monitoring

Tank-to-water “on” potentials and “IR-drop-free” potentials are measured by voltage transducers located near the rectifier. These potentials may

then be evaluated against NACE International CP criteria to verify that the CP system is providing adequate protection to the structure.

CP rectifier output voltage and current are measured by voltage and current transducers located near the rectifier. Rectifier output data may be analyzed over time to determine typical operating characteristics under various conditions. Deviations from typical measurements may indicate a problem or malfunction.

Voltage and current transducers installed near the rectifier for Tank 3 are shown in Figure 17 and Figure 18.

3.4.2 Corrosion rate and water quality monitoring

Each cathodically protected tank was outfitted with the corrosion rate and water quality monitoring equipment shown schematically in Figure 19.

The instantaneous corrosion rate in the non-cathodically-protected area at the bottom of the tank riser is monitored by a linear polarization resistance (LPR) probe called the Corrater® (Figure 20), manufactured by Rohrback-Cosasco Systems, Inc. Two carbon steel electrodes located on the probe tip are polarized by a small DC signal (e.g. ± 10 mV) with respect to each other and the resultant DC current is measured and converted to an instantaneous corrosion rate using Faraday's law. Figure 21 shows the Corrater installed in the base of Tank 3's riser pipe.

LPR sensors are unsuitable for use in cathodically protected environments, so the corrosion rate inside the tank bowl is monitored by an electrical resistance (ER) probe called the CORROSOMETER® (Figure 22), manufactured by Rohrback-Cosasco Systems, Inc. The probe is introduced through an access fitting on the tank (Figure 23). The sensing element is electrically connected to the tank so that it is exposed to the same level of CP as the tank surface. The resistance of the sensing element is then monitored as a function of time. Its resistance will increase as corrosion occurs and its cross-sectional area becomes smaller. Corrosion rate of the ER probe sensing element is calculated from the change in electrical resistance as a function of time. Thus, negligible change in resistance with time would indicate that negligible corrosion is taking place and that the CP system is effective.

Water quality in the tank riser pipe is monitored by a multi-parameter sensor called the PipeSonde (Figure 24), manufactured by the Hach Corporation. The PipeSonde measures pH, Oxidation-Reduction Potential (ORP), conductivity, dissolved oxygen (DO), turbidity, pressure and temperature simultaneously. Figure 25 shows the PipeSonde installed in the base of Tank 3's riser pipe.

One PipeSonde and one Corratel were installed at four additional locations in the distribution system for monitoring: the ground reservoir, the Conway Road vault, the 4th Street vault, and the Development Area of the North Country (DANC) water-treatment plant (Figure 26).

3.5 Results

3.5.1 CP system performance: Tank 3

The CP system in Tank 3 has been in continuous operation since its commissioning in January 2006, with the exception of brief downtime for minor mechanical repairs. Site personnel report that there was significant ice formation on the tank walls and on the water surface during the winter season. However, there have been no problems experienced with the icing of the CP system components.

Figure 27 shows four months of IR-drop free tank-to-water potential data from Tank 3, as reported by the SCADA system. (Data were unavailable from 23-26 June and 18-22 August.) The IR-drop free potential versus a saturated copper-copper sulfate (Cu/CuSO_4) reference electrode generally varied between -0.895 and -0.899 volts during the entire 4-month period. The only exception is a brief period of time on 2-3 July where the data "spiked" up and down. The reason for this is unknown.

NACE International Standard Recommended Practice RP0388-2001 requires a negative, polarized IR-drop-free tank-to-water potential of at least -850 mV relative to a saturated Cu/CuSO_4 reference electrode for complete corrosion control on the internal, submerged surfaces of steel water storage tanks. The IR-free potentials measured at Tank 3 meet this criterion, thus the CP system is operating properly and is preventing corrosion of the submerged interior surfaces of Tank 3.

Figure 28 shows the "on" potentials measured at Tank 3. They generally vary between 1.0 and 1.3 volts versus a saturated Cu/CuSO_4 reference

electrode. These potentials are within the range of values that would normally be expected.

Figure 29 and Figure 30 show the rectifier output voltage and current, respectively. Generally the output voltage varies between 2 and 3 volts, and the output current varies between 0.3 and 1.5 Amperes. These are within normal, expected ranges.

Thus, the above data indicate that the ice-free CP system in Tank 3 is operating properly and is providing adequate and continuous protection to the submerged surfaces inside the tank.

3.5.2 Corrosion rate and water quality data

The resistance of the ER probe element located in the bowl of Tank 3 has remained almost constant since it was installed. The resistance was 7.46 ohms at the start of the monitoring period covered by this report and 7.48 ohms at the end. This indicates that corrosion is not occurring in the submerged area of the tank bowl and reinforces the results above indicating that the CP system is providing corrosion protection.

An example of the instantaneous corrosion rate data measured by the LPR probe located in the unprotected bottom of the Tank 3 riser pipe is shown in Figure 31. The LPR electrodes were removed and replaced with new ones in September 2006 so that mass loss analysis could be conducted on them. Mass loss analysis was conducted in the laboratory in accordance with ASTM Standard G-1. The analysis indicated that the average corrosion rate was 4.1 mils/yr.

Example water quality and corrosion rate data for other locations in the distribution system are shown in Appendix E.

3.5.3 Tank 1

The construction of the new Tank 1 was completed in the fall of 2006, and the CP system was commissioned in November 2006. Data collection will continue for both tanks and all sensors over the coming year and performance will be monitored. Results of the ongoing investigation will be presented in the final report.

4 Metrics

There are two metrics used to validate the performance of the ice-free cathodic protection (CP) systems at Fort Drum. They are described below.

4.1 Metric 1: Validate that the CP systems are operating properly

The CP criteria contained in NACE International Recommended Practice (RP) 0388-2001 are the industry-standard metrics for evaluating whether or not a water tank CP system is operating properly. Tank-to-water potential measurements are used to determine compliance with the NACE CP criteria. The SCADA system periodically measures and records the tank-to-water potentials throughout the course of this project so that proper operation of the CP system can be validated.

4.2 Metric 2: Quantify the reduction in corrosion rate provided by the CP systems

Baseline corrosion rates are measured with an LPR sensor located in the unprotected area of the storage tank riser pipe. The LPR electrodes were removed for mass loss measurements per ASTM G1-03. The corrosion rate in the protected bowl of the water storage tank is monitored by an ER sensor. An increase in the resistance of the sensing element indicates that corrosion is taking place.

5 Economic Summary

5.1 Costs and assumptions

The direct costs of designing, procuring, and installing the ice-free CP systems described in this report totalled \$50,000 per tank.

It is estimated that a system of the same design could be installed at other locations for \$25,000 to \$40,000 per tank, depending on the tank configuration.

5.2 Projected Return on Investment (ROI)

The projected ROI originally estimated in the PMP for this project was 20.55. The calculation has been updated based on actual data collected during this project (Appendix F). The revised projected ROI is 11.75.

6 Recommendation

It is recommended that the managers of U.S. military installations fully consider utilizing modern ice-free cathodic protection systems on water storage tanks subject to freezing temperatures to prevent corrosion, extend infrastructure service life, and avoid potentially costly leaks and component replacement.

7 Implementation

It is recommended that this technology be adopted widely and implemented by inclusion in the applicable Unified Facilities Guide Specifications (UFGS) and Technical Manuals (TM). In particular, the primary document in which to codify these recommendations are UFGS-26 42 15.00, *Cathodic Protection System – Steel Water Tanks* (April 2006) as well as UFGS-26 42 22.00, *Cathodic Protection System – Steel Water Tanks* (April 2006). Inclusion in the NACE publication, RP0388-2001, the AWWA Standard #D104-04, EM 1110-1-4008, ETL #1110-9-10, ETL #1110-3-474, and MIL-HDBK-1004/10 would also be beneficial. Army adoption of these recommendations would be aided by inclusion in Army TM 5-811-7, *Electrical Design, Cathodic Protection* as well as TM 5-692-1, *Maintenance of Mechanical and Electrical Equipment at Command, Control Communications, Intelligence, Surveillance, and Reconnaissance (C4ISR) Facilities*.

8 Conclusions

This project demonstrated the benefits of ice-free cathodic protection systems installed in two elevated water storage tanks subject to cold weather. The ice-free CP systems are operational in elevated storage tanks #1 and #3 at Fort Drum.

Tank-to-water IR-drop-free potentials are being monitored by Fort Drum's existing SCADA system. The potentials recorded to date for Tank #3 meet the water tank CP criteria required by NACE International Standard Recommended Practice RP0388-2001., thus the CP system is operating properly and is preventing corrosion of the submerged interior tank surfaces.

CP rectifier voltage and current outputs are being monitored so that typical operating characteristics under various conditions can be determined. Deviations from normal performance that may indicate a problem can be detected immediately.

The water-chemistry and corrosion-rate sensors installed in the tanks, riser pipes, and selected locations in the water distribution system at Fort Drum are providing data so that the DPW can monitor real-time conditions in the system.

Performance results for the CP system installed in the newly constructed Tank #1 will be included in the final report.

Figures

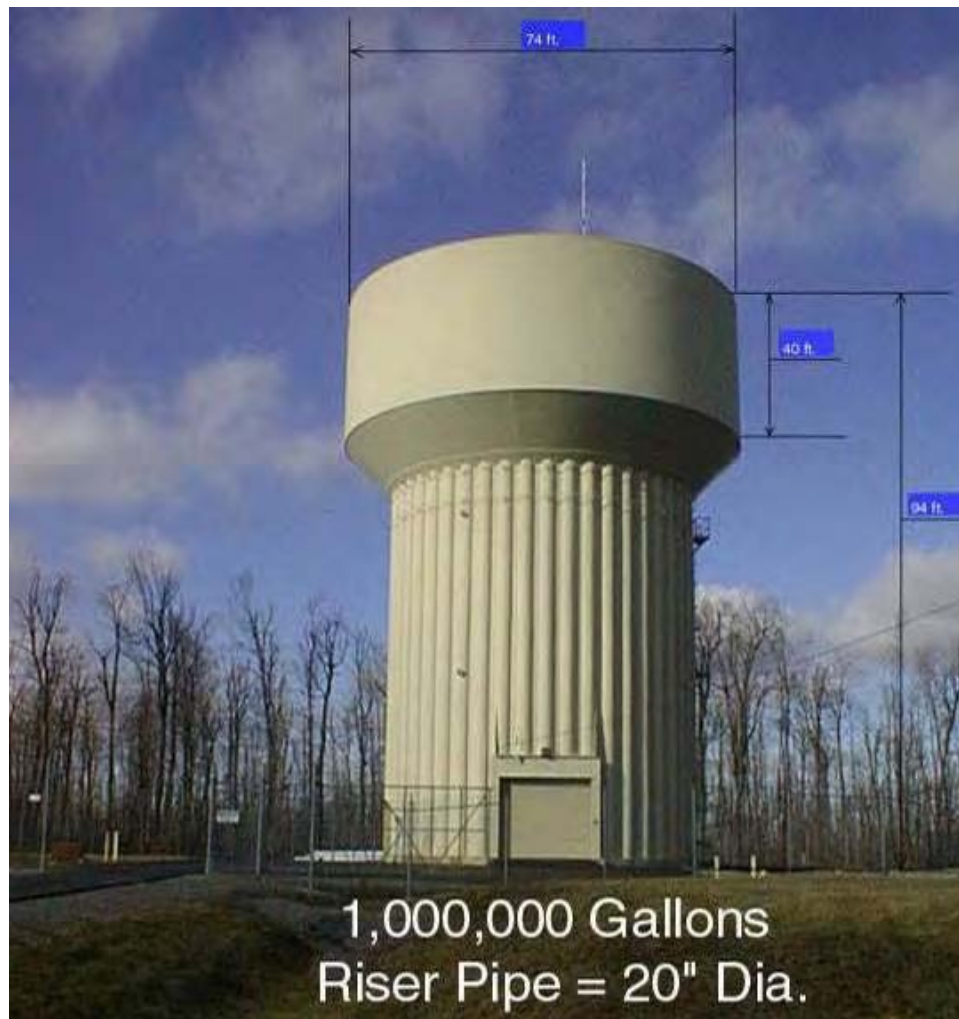


Figure 1. Fort Drum Tank 3.



Figure 2. Close-up of coating damage and corrosion inside Tank 3.



Figure 3. Fort Drum Tank 1 under construction.

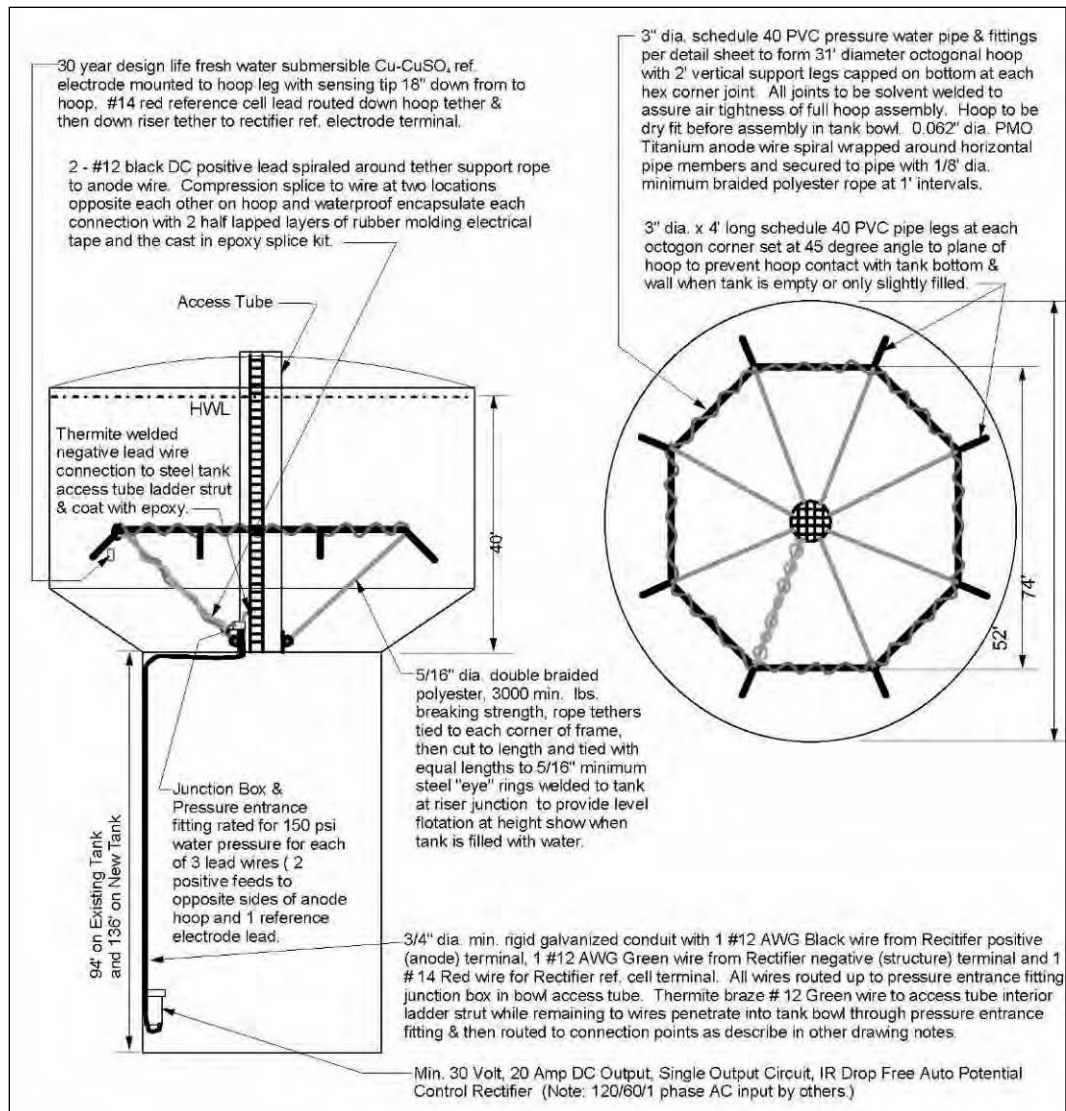


Figure 4. Initial ice-free CP system design featuring tethered octagonal PVC pipe buoy.

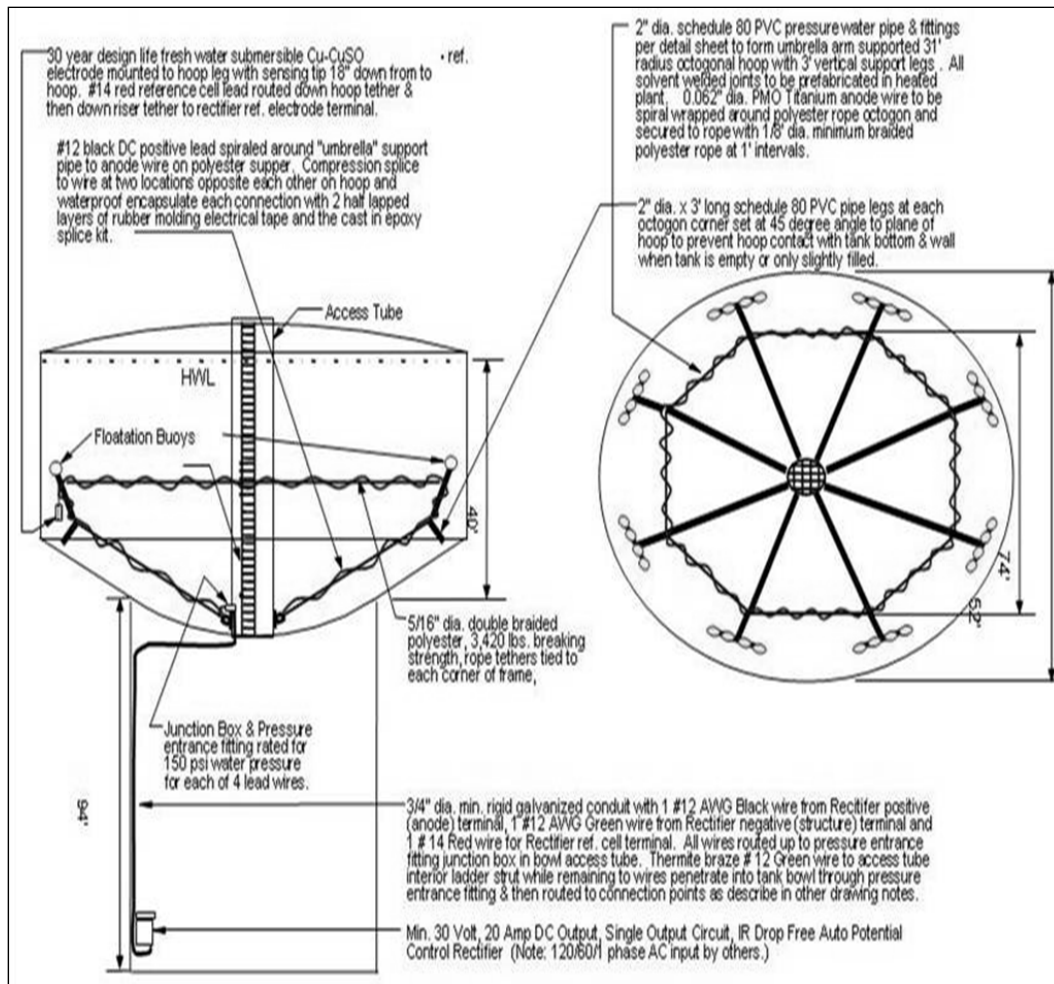


Figure 5. Schematic of as-installed CP system featuring "umbrella" style support structure.

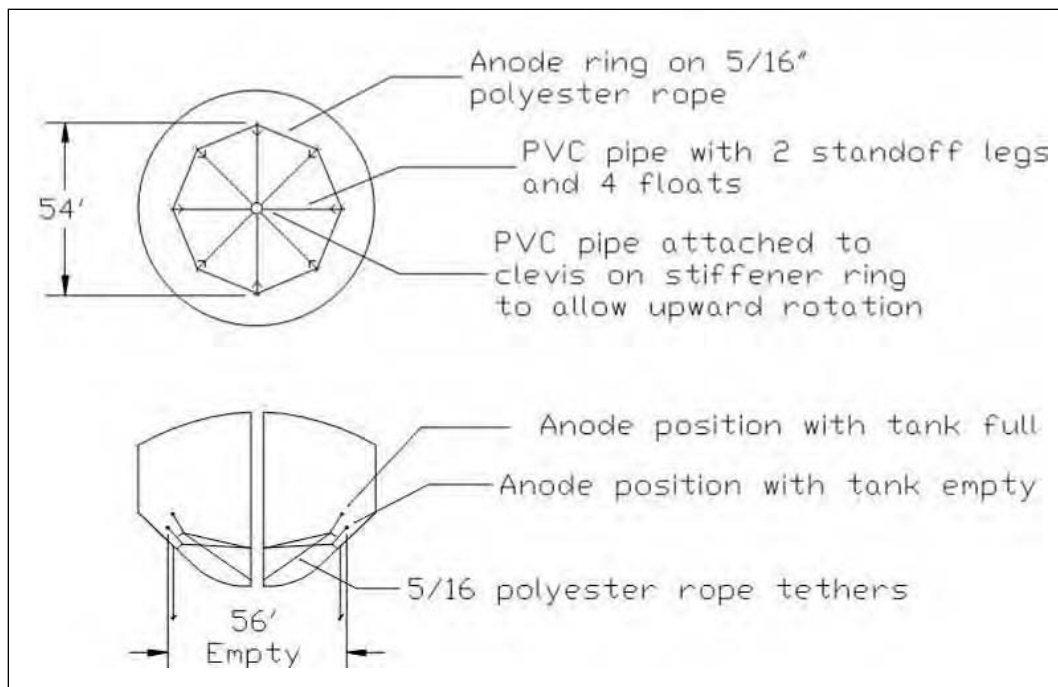


Figure 6. Additional schematic of final CP system design.

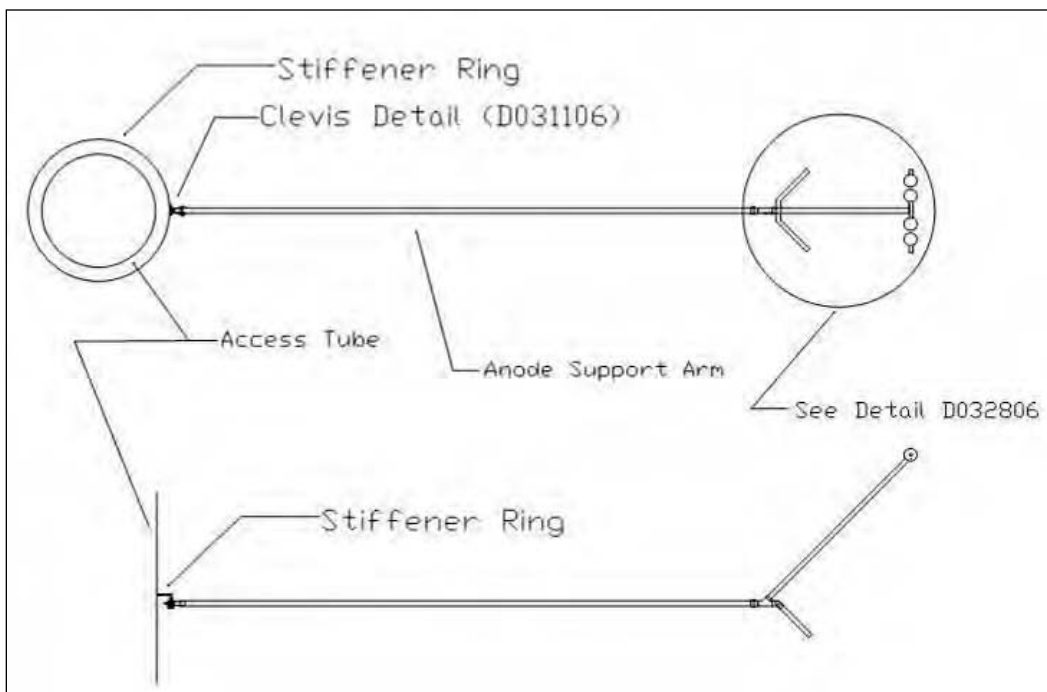


Figure 7. Anode support arm detail.

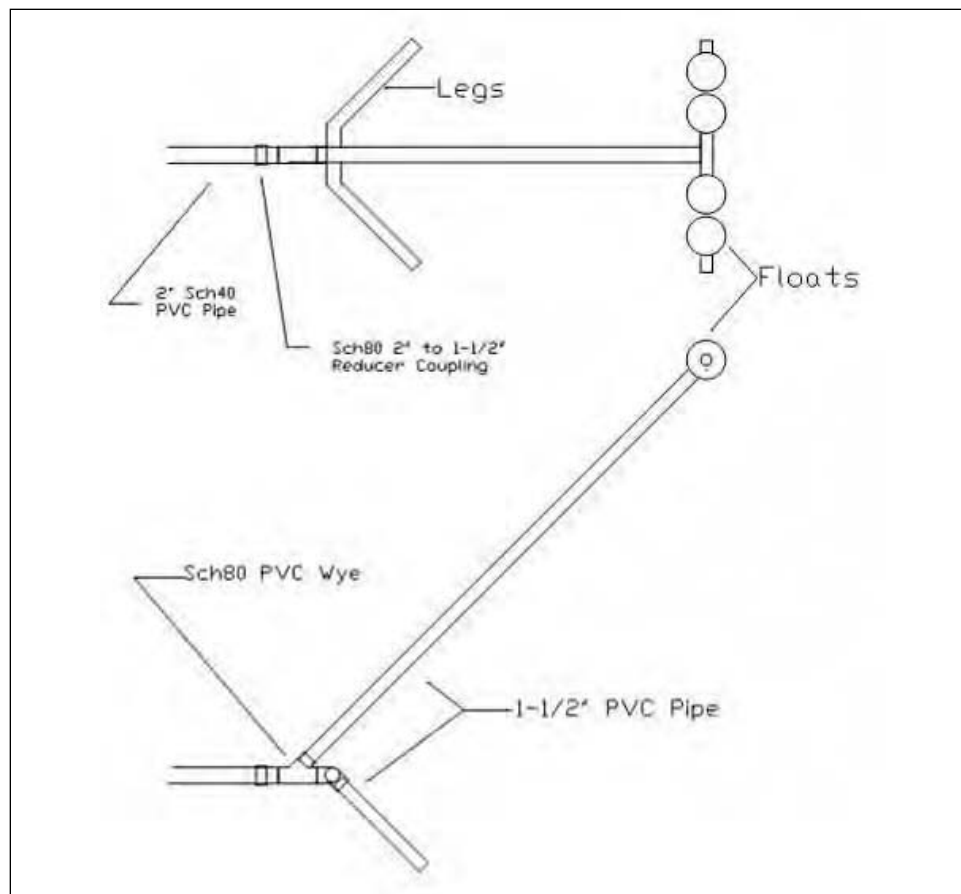


Figure 8. Float detail for anode support arm.

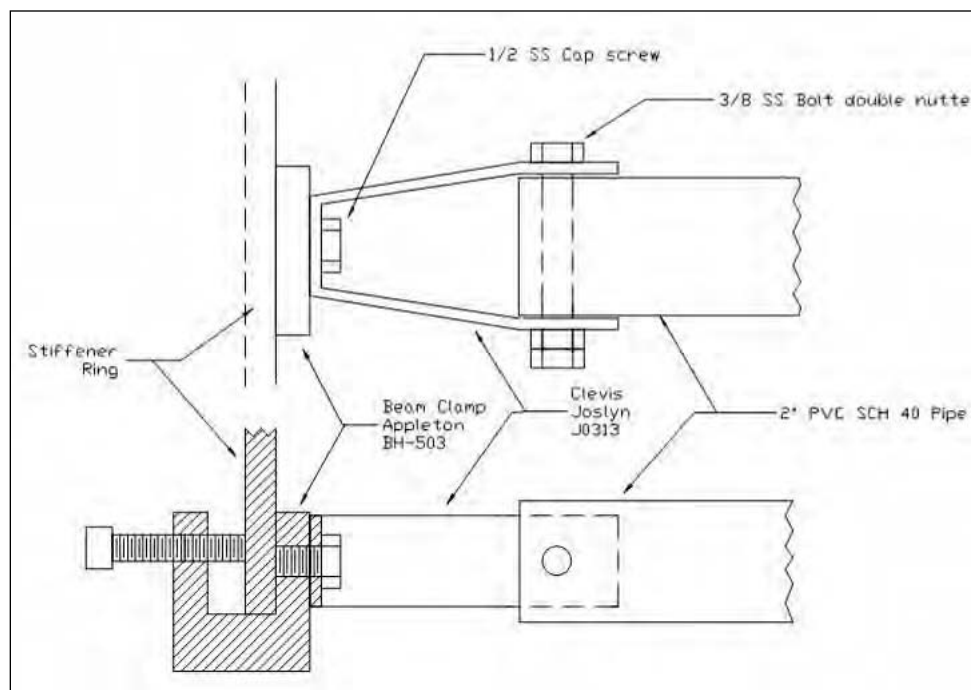


Figure 9. Clevis detail for anode support arm.



Figure 10. Components of CP system being inserted into the tank.

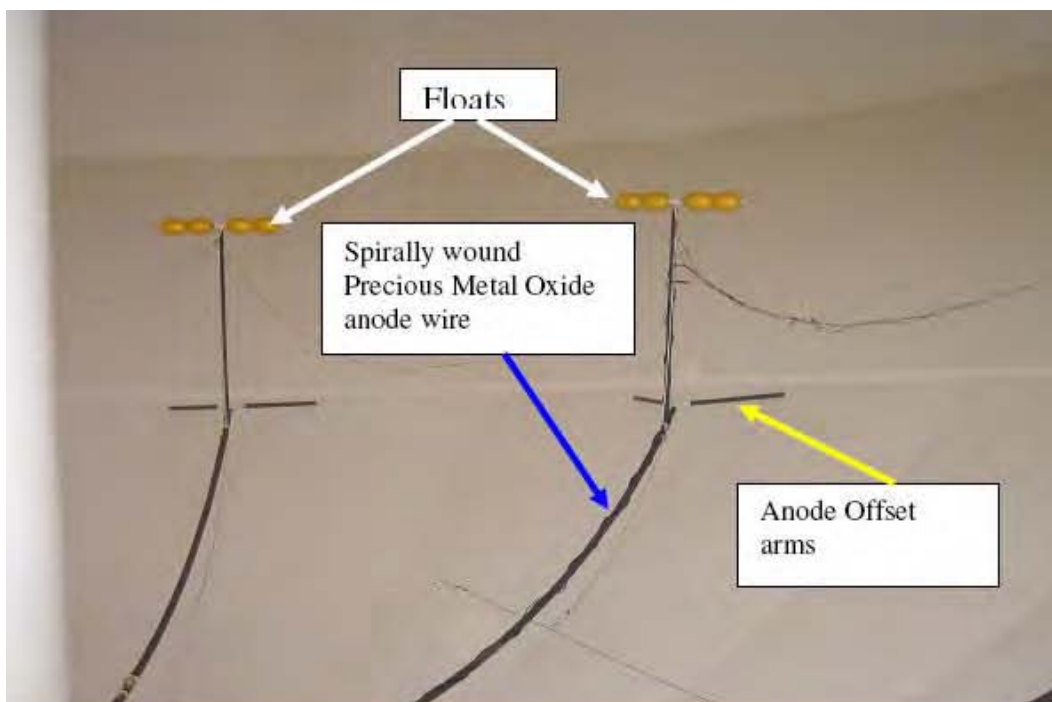


Figure 11. As-installed appearance of a portion of the ice-free CP system in Tank 3.

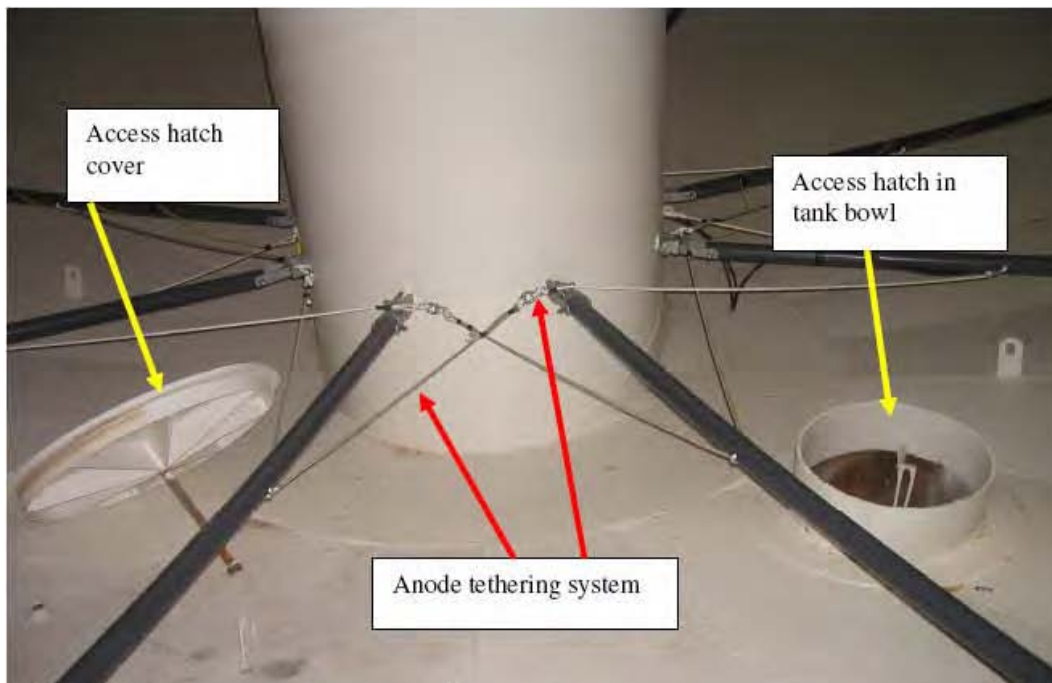


Figure 12. Illustration of ice-free anode tethering system at "dry riser" in center of tank.



Figure 13. Penetration fitting for anode electrical connections on tank interior.



Figure 14. Penetration fitting in access tube on tank exterior for anode electrical connections on interior.



Figure 15. Top view of anode supports as tank fills with water.



Figure 16. Rectifier used to energize the ice-free CP system in Tank #3.



Figure 17. Voltage transducers installed near rectifiers for tank-to-water potential and rectifier output voltage monitoring.

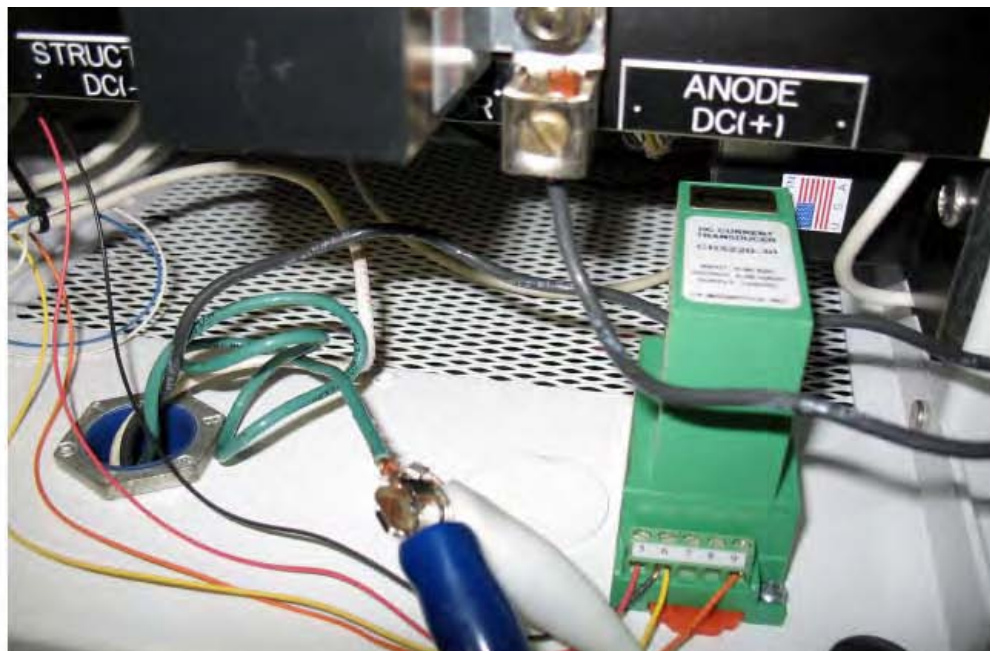


Figure 18. Current transducer installed to monitor rectifier current output.

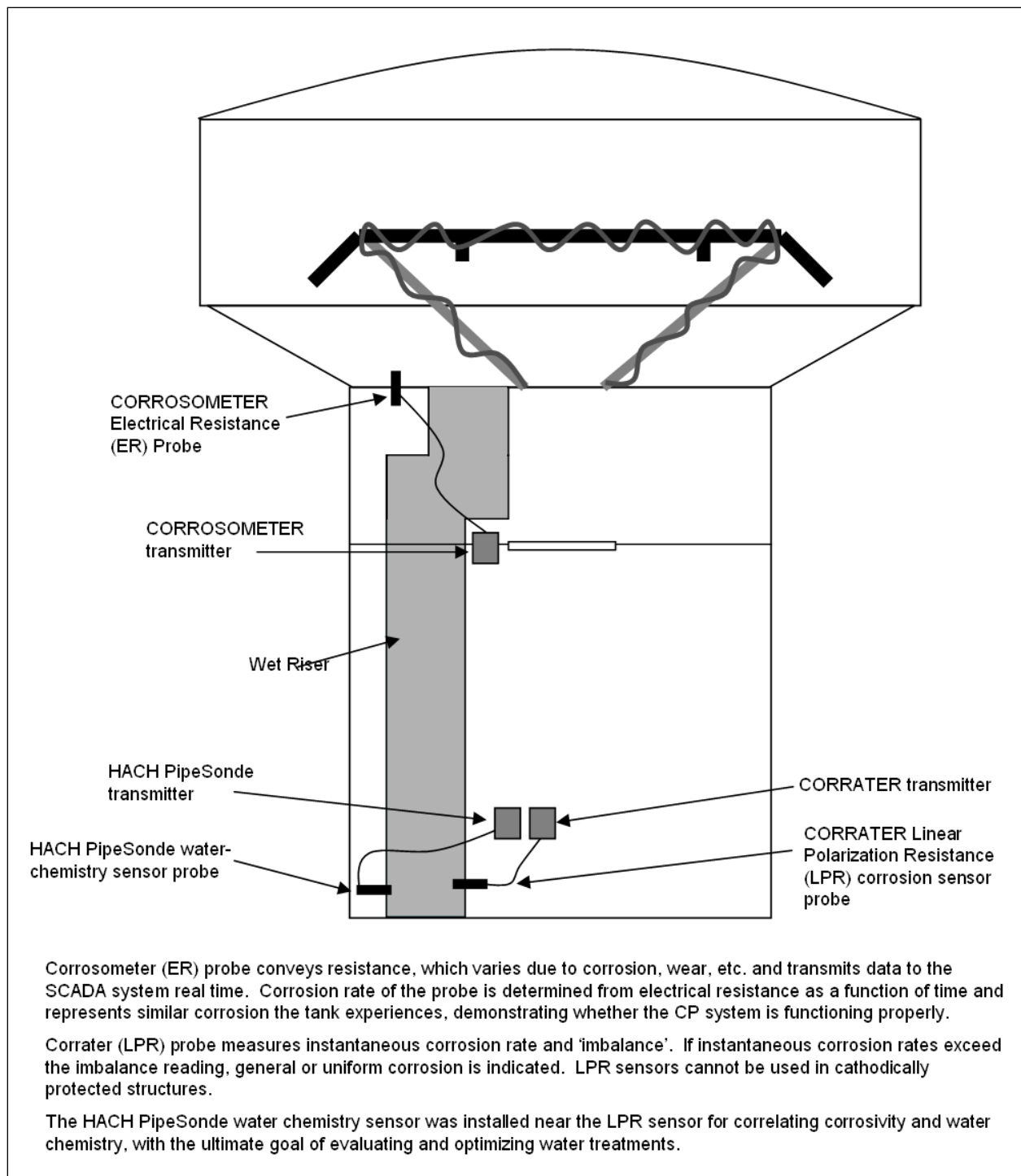


Figure 19. Schematic of tank corrosion monitoring equipment.



Figure 20. Corrater linear polarization resistance (LPR) probe.



Figure 21. Corrater probe installed in the Tank 3 riser.



Figure 22. CORROSOMETER electrical resistance corrosion rate probe.

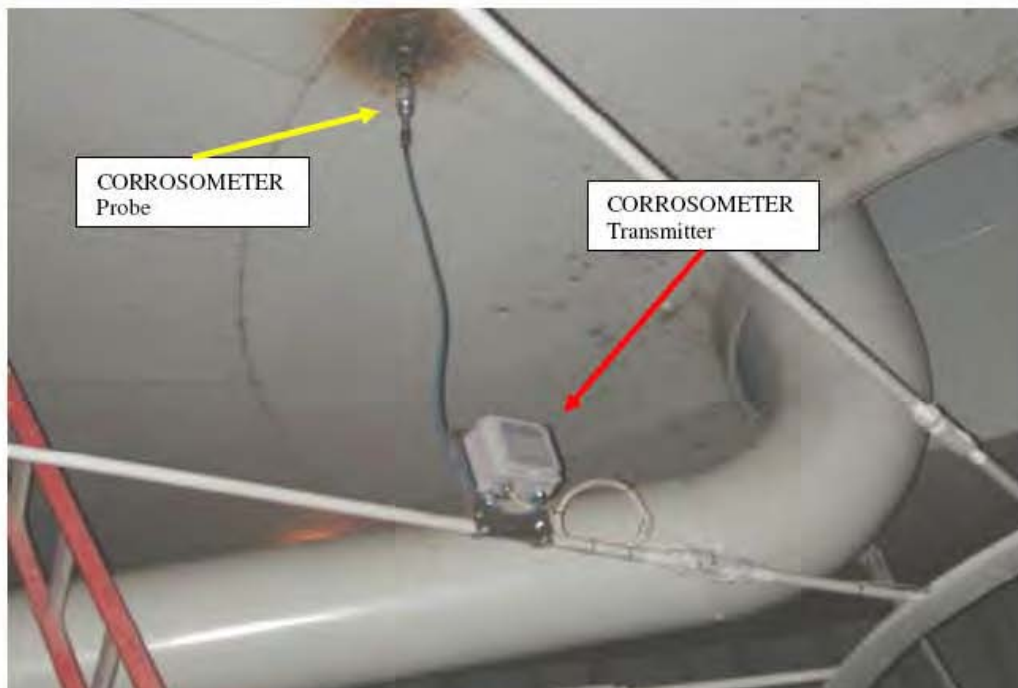


Figure 23. CORROSOMETER probe and transmitter as installed in Tank #3.



Figure 24. Hach PipeSonde probe.



Figure 25. PipeSonde probe installed in Tank 3 riser.

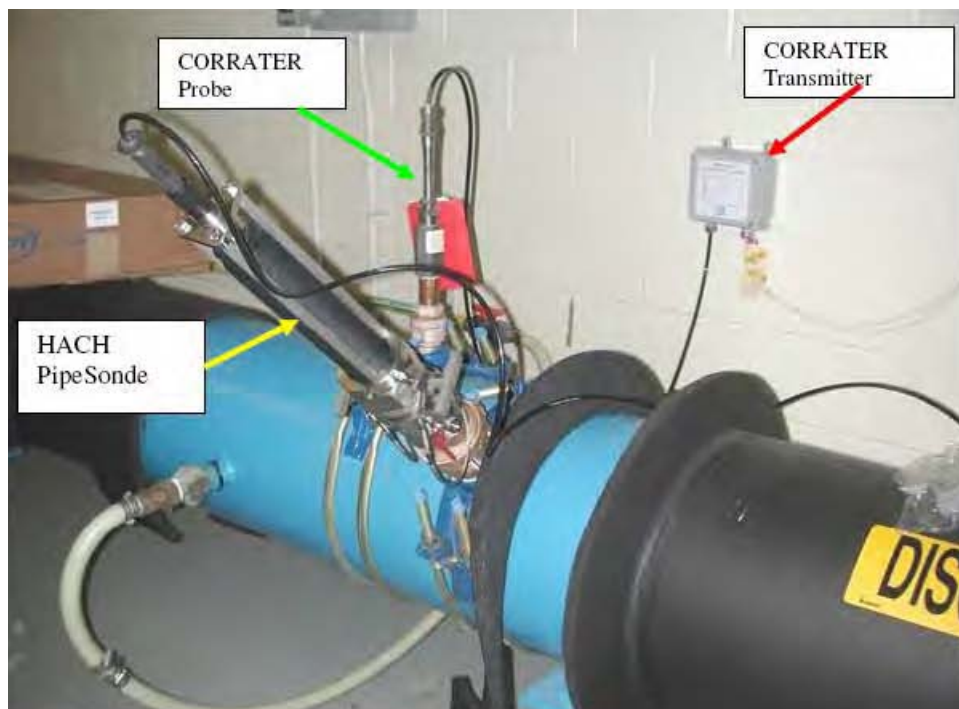


Figure 26. Corrosion rate and water quality sensors installed at DANC water treatment plant.

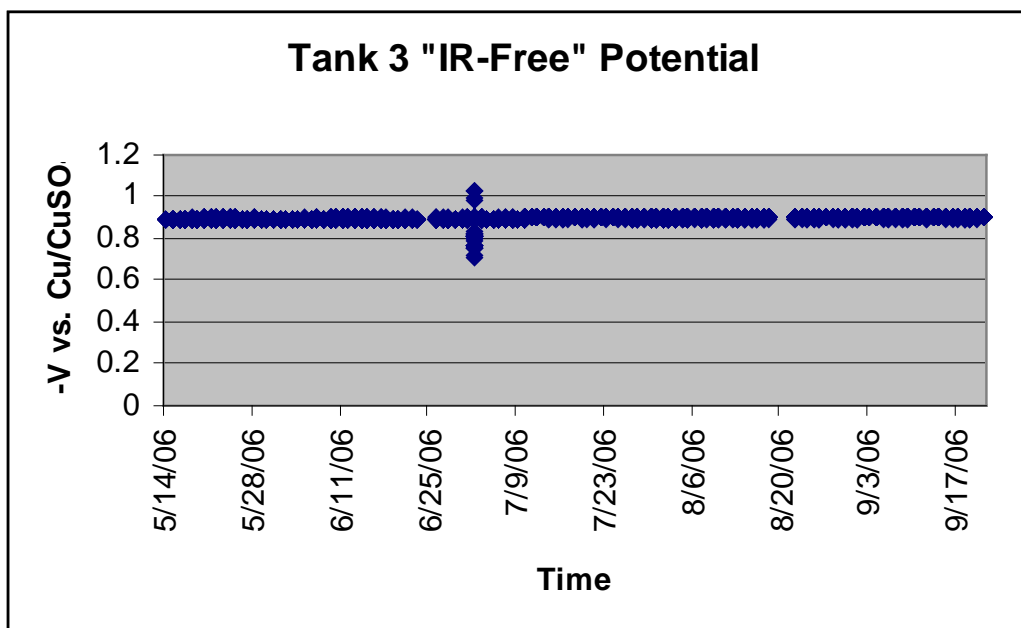


Figure 27. Tank 3 "IR-free" tank-to-water potentials.

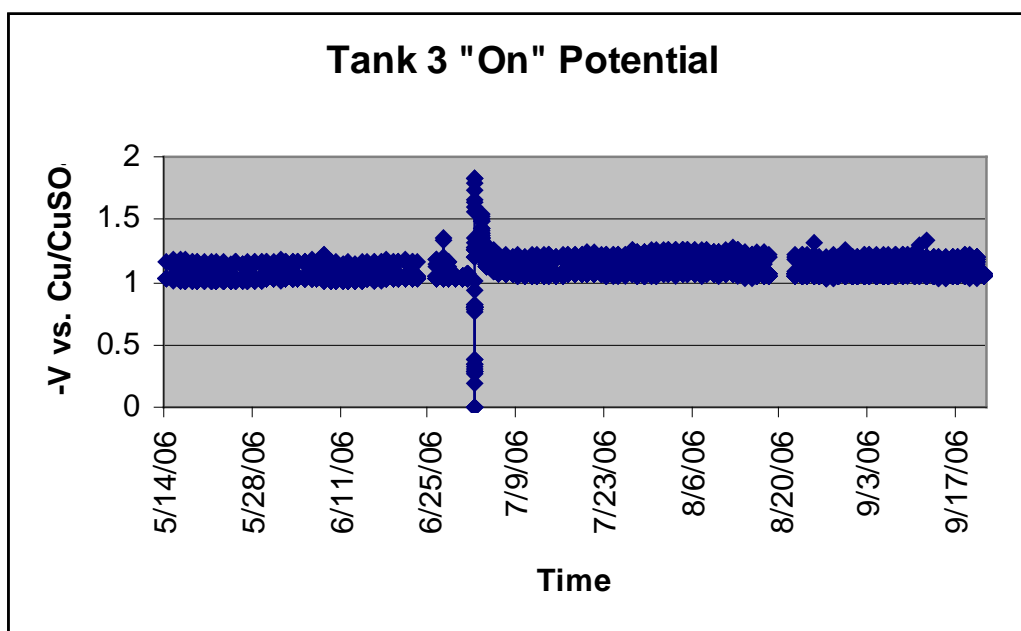


Figure 28. Tank-to-water "on" potentials at Tank 3.

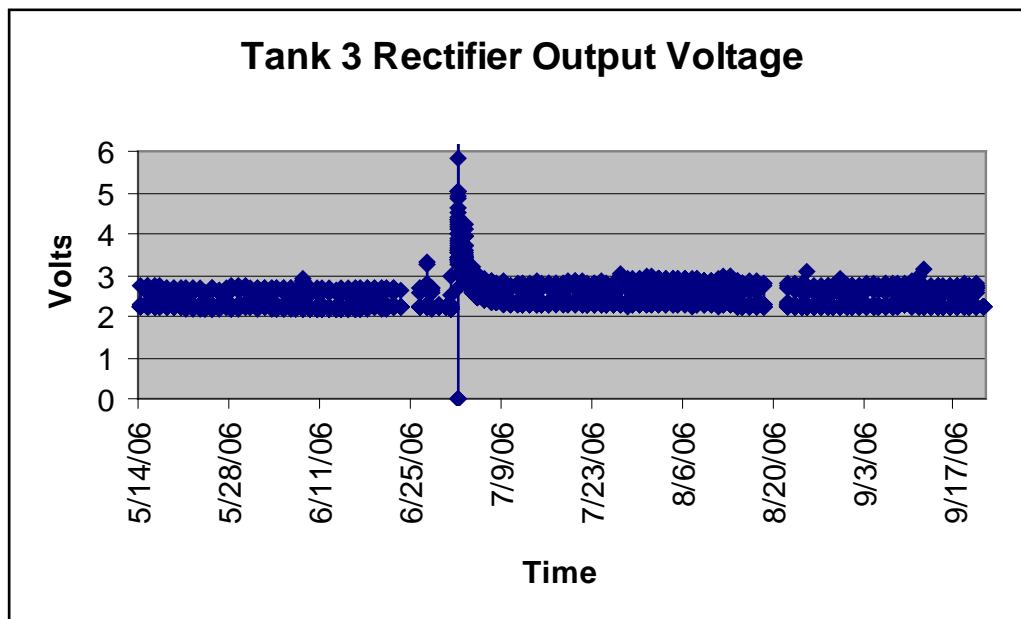


Figure 29. Tank 3 CP rectifier output voltage.

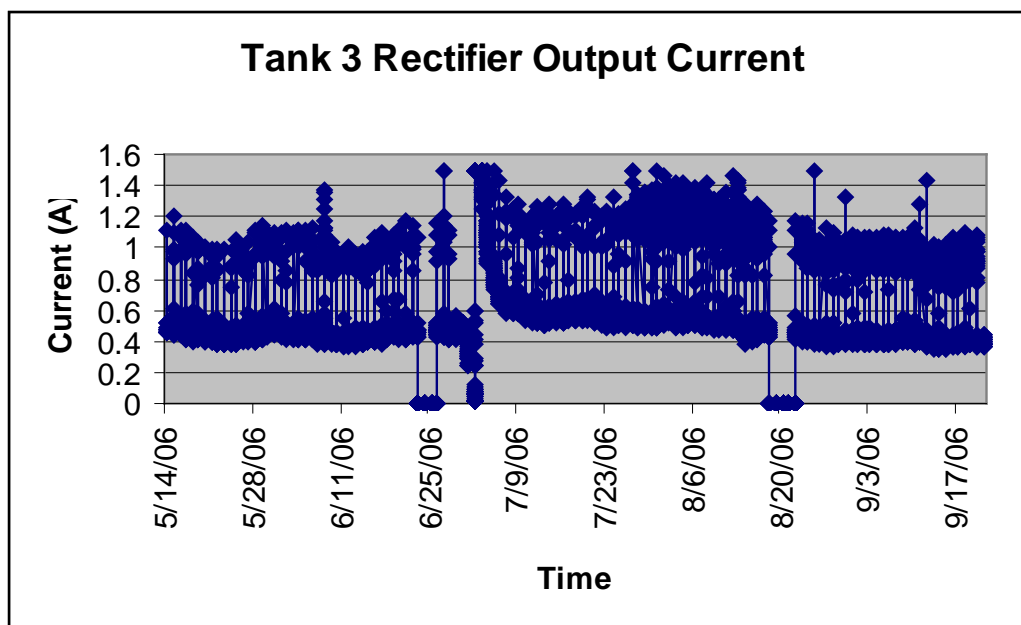


Figure 30. Tank 3 CP rectifier output current.

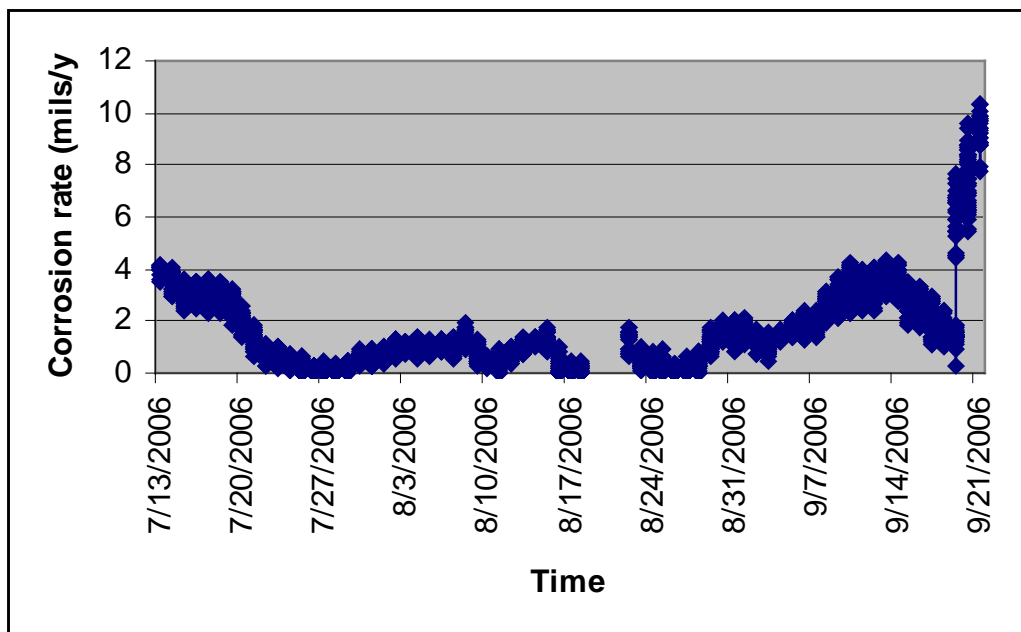


Figure 31. Example instantaneous corrosion rate data from unprotected area at bottom of Tank 3 riser.

Appendix A: Project Management Plan for CPC Project AR-F-318

CORROSION PREVENTION AND CONTROL PROJECT PLAN
Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

TRISERVICE PROGRAM
ARMY FACILITIES

CORROSION PREVENTION AND CONTROL PROJECT PLAN

Ice Free Cathodic Protection Systems for Water Storage Tanks
at Fort Drum

13 July 2004

Submitted By:

Vincent F. Hock

U. S. Army Engineer Research & Development Center (ERDC)
Construction Engineering Research Laboratory (CERL)

Comm: 217-373-6753

(Project Number to be *assigned by OSD when approved*)

CORROSION PREVENTION AND CONTROL PROJECT PLAN
Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

1. STATEMENT OF NEED

PROBLEM STATEMENT: Fort Drum, IMA-NERO, HQ IMA, and ACSIM have identified elevated steel potable water storage tanks and the associated piping as critical components of their infrastructure needed to support the mission. Soldiers, their families, and civilian employees depend on them to provide a safe and reliable source of water for drinking, bathing, washing, and cooking. Water storage tanks and piping also provide water storage capacity and pressure to the distribution system for firefighting including aircraft deluge systems, building fire suppression systems, and fire hydrants.

Water storage tanks and piping should have a service life of 50 to 75 years. However, severe corrosion inside the bowl of the tank and in the associated piping shortens the service life to as little as 20 years due to leaks and/or structural problems. Throughout the tank's life, corrosion products (i.e. "rust") will enter the potable water and will cause water quality problems including discoloration ("red water"), taste, and odor. In some cases the water may exceed the maximum contaminant level for iron of 0.3 mg/l as specified in the Environmental Protection Agency's National Secondary Drinking Water Regulations. Ladders that are used by maintenance personnel to access the inside of the water tank will corrode and become a safety hazard. The unplanned loss or failure of a storage tank and/or piping usually results in the catastrophic loss of adequate fire suppression capability and can endanger lives and property.

It is standard practice to install cathodic protection (CP) systems inside water storage tanks to prevent corrosion from occurring. However, conventional CP systems are often prematurely damaged or destroyed when surface ice forms in the tank in very cold environments. For example, the CP system in one of Fort Drum's potable water storage tanks was completely destroyed in 2000 due to ice damage after only a few years of service. This is a problem at all DoD installations with water storage tanks located in areas with cold winters.

Conventional CP systems must be repaired or replaced immediately to prevent corrosion damage inside the tank. This is not a simple or inexpensive task; it requires a specially trained corrosion engineer to design a proper replacement, and workers must climb and enter the tank to install it. The most likely scenario is that once the CP system fails, the inside of the tank will remain unprotected for months or even years until funds can be obtained to replace it, especially in cold climates.

Protective coatings alone are insufficient to prevent corrosion; in fact, accelerated corrosion can take place at defects in the coating if there is not a properly functioning CP system to prevent it. Virtually all coatings have defects, so if there is no CP, accelerated corrosion is likely to occur.

CORROSION PREVENTION AND CONTROL PROJECT PLAN
Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

IMPACT STATEMENT:

If this project is not funded, potable water storage tanks located in cold climates will be vulnerable to severe corrosion damage and failures and can require replacement after as little as 20 years of service, as opposed to the expected 50 to 75 years. The unplanned failure of a water storage tank can result in catastrophic loss of adequate fire suppression capability and thereby endangers lives and property. It can also impact the military mission by delaying deployment of troops due to inability to operate aircraft deluge (fire suppression) systems and/or lack of water to carry out critical activities such as the filling of portable water tanks that are shipped with forces being deployed to arid regions. Active corrosion in water storage tanks can result in discolored, bad tasting, and/or malodorous water that is unfit for drinking and washing. In some cases the water may exceed the maximum contaminant level for iron of 0.3 mg/l as specified in the Environmental Protection Agency's National Secondary Drinking Water Regulations.

2. PROPOSED SOLUTION

TECHNICAL DESCRIPTION: Industry has developed an innovative design for an ice-free impressed current CP system to protect the interior surfaces of water storage tanks in cold climates. This new system uses ceramic-coated wire anodes along with a flotation and support system that keeps the anodes submerged in water underneath surface ice, regardless of the water level. Because the anodes and their supports are kept away from the ice, they will no longer be subject to ice damage.

Ice-free CP systems will be designed and installed in two (2) elevated potable water storage tanks at Fort Drum, NY. The systems will be monitored to ensure that they provide continuous protection to the structure and that they remain free of ice damage. Training on the proper testing and maintenance of the system will be provided to the Fort Drum DPW. The water treatment program will be modified as needed to optimize it for the new conditions.

The benefits of implementation of the ice-free CP system are the avoidance of premature tank, pipe, and CP system failure, and avoidance of the resulting fire suppression system failures, mission delays, and water quality problems. A properly functioning CP system will enable the tank to meet or exceed its planned service life of 50 to 75 years, instead of requiring replacement due to corrosion failure in 20 years.

Implementation of this technology at Fort Drum is projected to have an ROI of 20.55, and a total savings of \$20,554,582.

Technology Maturity:

Impressed current cathodic protection (CP) systems represent a mature technology to prevent water-side corrosion of potable water storage tanks. CP is an electrical method

CORROSION PREVENTION AND CONTROL PROJECT PLAN
Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

for preventing corrosion in which direct current (DC) is continuously supplied to a submerged or buried metallic structure to stop the natural corrosion processes from occurring. An impressed current CP system generates direct current by using a rectifier. The rectifier is connected to anodes that discharge the current through the soil or water and onto the protected structure.

In the past, large and heavy (approximately 40 pounds each) iron-silicon or graphite anodes were used for CP systems in water storage tanks. The anodes were submerged in the water by suspending them from the roof of the tank using wires and cables. Such systems were vulnerable to failure not only due to ice, but also due to the weight of the suspended anodes pulling on the wire and electrical connections.

Innovative ceramic-coated anodes have been used as a lightweight alternative to the silicon-iron and graphite anodes in recent years. These anodes are typically made by depositing mixed metal oxides onto titanium substrates, and they only weigh 4 ounces each. The ceramic anode makes corrosion protection available at one-half the life cycle cost of previous technologies and eliminates the problems caused by large, heavy anodes.

Industry has created an innovative CP system design for water storage tanks that incorporates the ceramic anode and overcomes the problems of anode fragility and ice accumulation, yet still meets the requirement of submerging the anode in the water such that it does not make electrical contact with the tank. First, the anode is supplied in the form of a ceramic-coated wire (Figure 1) instead of the more traditional segmented rod shape. The wire is then wrapped around a PVC hoop to provide strength as well as flotation. The hoop is tethered to prevent it from coming into contact with the ice layer. Figure 2 shows a schematic of this new design.

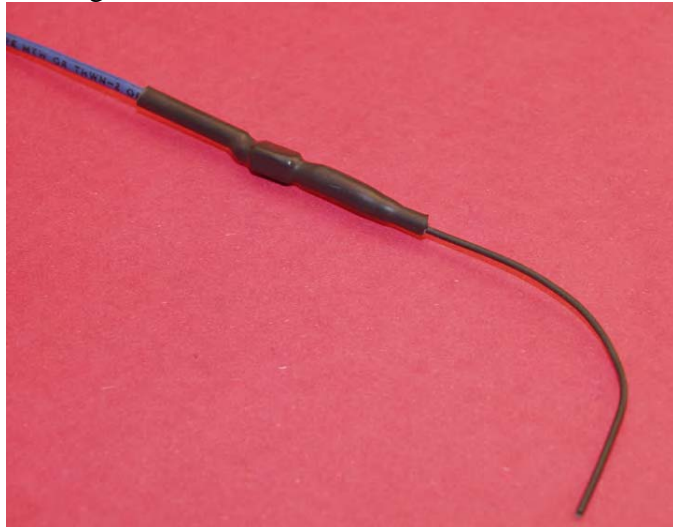


Figure 1. a. Fort Drum water storage tank; b. Ceramic-coated wire anode.

CORROSION PREVENTION AND CONTROL PROJECT PLAN
Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

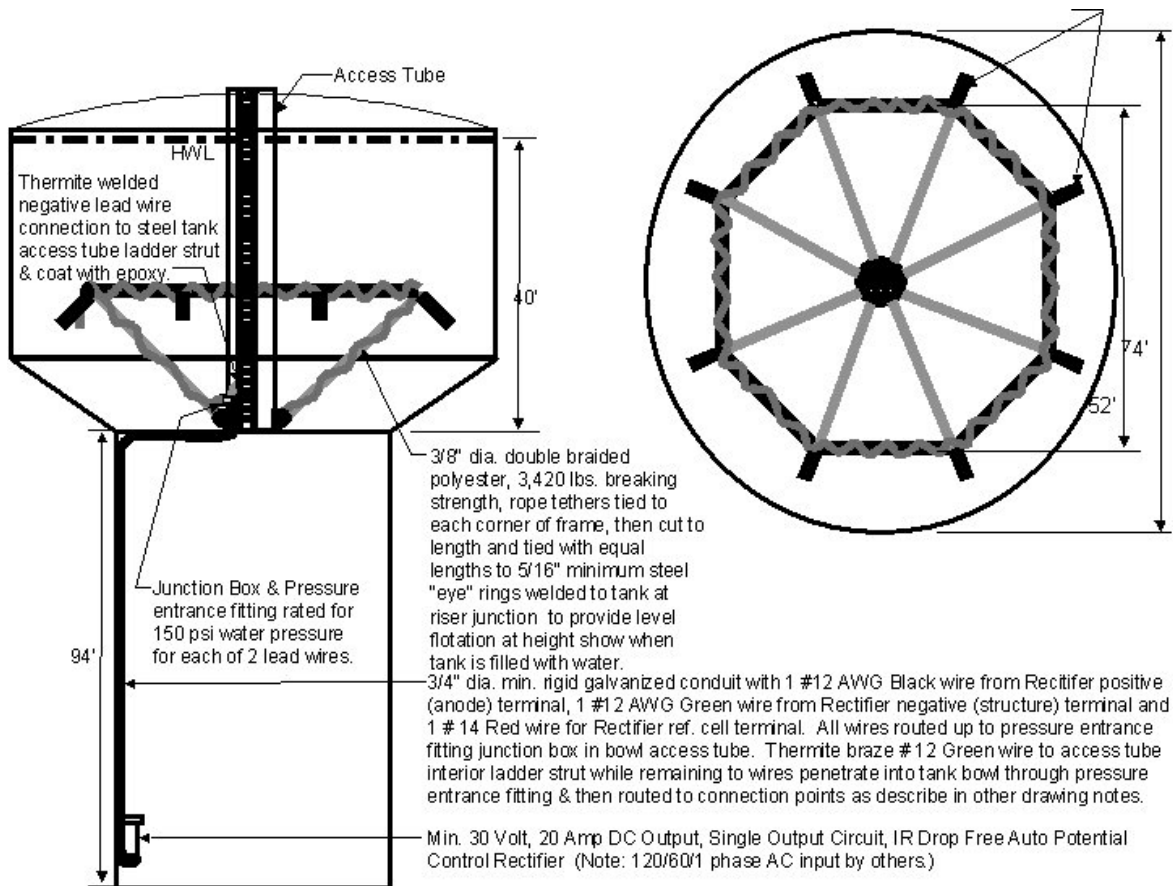


Figure 2. Schematic of ice-free CP system.

RISK ANALYSIS: This is a low risk project, as the CP system components are available commercially, and have been successfully field tested in similar applications. Also, the sites for implementation of this project at Fort Drum and plans for implementation of this project have been coordinated with Mr. Tom Ferguson, (Chief, Operations & Maintenance Division). The project will not be parsed into phases.

EXPECTED DELIVERABLES AND RESULTS/OUTCOMES: The industry has recently developed cost effective ice-free CP systems that are able to continue operating properly in spite of adverse conditions inside the water tank. The corrosion protection needs of two (2) elevated potable water storage tanks at Fort Drum will be assessed. Specifications for ice-free cathodic protection systems will be developed, and the systems will be constructed and installed. Commercially available innovative ceramic anodes will be used. Training on the maintenance of the new CP systems will be provided to the appropriate persons at Fort Drum. The efficacy of the ice free CP systems will be determined. It is expected that they will prevent corrosion on the interior tank surfaces

CORROSION PREVENTION AND CONTROL PROJECT PLAN
Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

and that they will not be damaged by icing conditions. It is expected that a properly-operating CP system will extend tank and piping life to the design life of 50 years. Maintenance will be reduced, safety will be increased, and water quality problems due to severe tank corrosion will be avoided.

Unified Facilities Guide Specifications (UFGS), Engineering Instructions (EI), Technical Instructions (TI), and Technical Manuals (TM), including updates, along with a final report describing the details of the project, will be developed and posted on the OSD Corrosion Exchange website under “Spec & Standards” and “Facilities SIG.” In addition, the draft documents will be posted on the ERDC-CERL Corrosion Control Program Technology Program (CCTP) website.

PROGRAM MANAGEMENT: The Project Manager will be: Mr. Vincent Hock. The Associate Project Manager will be: Ms. Vicki Van Blaricum. Mr. Martin Savoie is Chief, ERDC/CERL Materials & Structures Branch. The stakeholders are: the Installation DPW POC, Mr. Tom Ferguson (Chief, Operations & Maintenance Division, Fort Drum), Mr. Bill Dancy (IMA-NERO), Mr. Paul Volkman (HQ-IMA), Mr. David Purcell, (HQ-ACSIM), as well as Triservices WIPT representatives, Ms. Nancy Coleal (AFCESA/CESM), and Mr. Tom Tehada (NFESC).

The customer is: Mr. Tom Ferguson, Chief, Operations & Maintenance Div, Fort Drum. The technology has been requested by Fort Drum to help improve corrosion control of their critical systems.

Fort Drum has provided matching funding in the amount of \$500K for this project. (See attached Memorandum from ACSIM Director for Facilities and Housing in Appendix 2). Coordination with the Army Corrosion Program Office will be through Mr. Hilton Mills (AMC).

This is a TriService Project. Funds have been requested for Air Force and Navy representatives to participate in the evaluation of technology implementation. The approach for project performance will include use of Type I –In house, organic capabilities, and Type II Existing Contact. A Type II Existing Contractual Agreement is expected to be utilized for this project two months after receipt of funds.

3. COST/BENEFITS ANALYSIS

a. Funding (\$K):

Funding Source	OSD	Fort Drum Matching
Labor	250	--

CORROSION PREVENTION AND CONTROL PROJECT PLAN
Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

Materials	200	500
Travel	40	--
Report	40	--
Air Force/Navy Participation	10	-
TOTAL (\$K)	500	500

Development Project Budget

The \$1M budget is realistic and adequate for the project scope. This budget has been developed based on a detailed needs assessment for the water storage tanks in cooperation with the Fort Drum DPW Office, including Mr. Tom Ferguson, Chief of Operations and Maintenance Division. Fort Drum plans to provide \$500K in matching funds for FY05. ERDC-CERL has conducted a market survey to validate the costs for this project, which have also been extrapolated from ERDC-CERL's extensive previous experience in the area of cathodic protection.

This project has a high potential ROI>10 (20.55) as well as a significant cost savings of \$20,554,582 as shown below.

b. Return-On-Investment Computation

- 1) Projected Useful Life Savings (ULS) is equal to the "Net Present Value (NPV) of Benefits and Savings" calculated from the Spreadsheet shown in Appendix 1 that is based on **Appendix B of OMB Circular A94**.

ULS= \$20,554K (from OMB Spreadsheet in Appendix 1. Assumptions for this calculation are also given in Appendix 1).

- 2) Project Cost (PC) is shown as "Investment Required" in OMB Spreadsheet in Appendix 1; **PC= \$1,000K**.

$$\text{Potential ROI} = \frac{\text{ULS}}{\text{PC}} = \frac{\$20,554\text{K}}{\$1,000\text{K}} = 20.55$$

The calculated ROI for this project, which is based on current best practices, projected maintenance and rehab cost, has the potential to increase over the multiple year implementation due to reduction in down time, which will result in increased indirect savings.

- c. Mission Criticality:** The operational benefits of implementation of this technology for these mission critical systems are: (1) enhanced safety and reliability for water systems due to reduced probability of failure, and (2) reduced maintenance and enhanced sustainability, due to the reduction in ice damage to

CORROSION PREVENTION AND CONTROL PROJECT PLAN
Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

the CP system, and therefore increased probability that the CP system will be maintained in working order.

4. **SCHEDULE**

MILESTONE CHART

EVENT	TIME (months after receipt of funds)
Award Contract	2
Select Potable Water Tanks and collect field data required for design	4
Design ice-free CP systems and select monitoring devices	6
Install ice-free CP systems and monitoring devices	8
Complete Training	15
Complete Documentation (includes Final Report, Procurement Specification, Ad Fliers	16
Complete potential ROI validation	18

- a. Note: If project is approved, *bi-monthly status reports will be submitted* (i.e. starting the first week of the second month after contract award and every two months thereafter until final report is completed). These reports will be submitted to the DoD CPC Policy & Oversight office. These reports will include project number, progress summary (and/or any issues), performance goals and metrics and upcoming events.
- b. Examples of performance goals and metrics: include achieving specific milestones, showing positive trend toward achieving the forecasted ROI, reaching specific performance quality levels, meeting test and evaluation parameters, or successfully demonstrating a new system prototype.

Development Project Schedule

This project to implement cathodic protection upgrade and remote monitoring units project will be completed, including final report, within 18 months. **The goals of the project are: restoration of cathodic protection systems to optimum operating conditions using ice-free designs incorporating ceramic-coated anodes. The objective is proper design and installation of the CP system, and continuous ice-free operation.** Detailed milestones are given in the schedule section. Implementation of the ice-free cathodic protection systems, including ceramic anodes, will be provided by Contractors. ERDC-CERL will provide overall management, contract monitoring and provide bi-monthly reports. Existing contract mechanisms, such as IDIQ and BAA will be used. ERDC-CERL will be able to award the contracts within 60 days of receipt of funds. The schedule has been coordinated with Fort Drum DPW. Potential contractors have been identified.

CORROSION PREVENTION AND CONTROL PROJECT PLAN
Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

5. IMPLEMENTATION

a. Transition approach: Where applicable, Unified Facilities Guide Specifications (UFGS), Engineering Instructions (EI), Technical Instructions (TI), and Technical Manuals (TM), including updates, along with a final report describing the details of the project, will be developed and posted to the OSD Corrosion Exchange website under “Spec & Standards” and “Facilities SIG.” In addition, the guidance will be ERDC-CERL Corrosion Prevention and Control Program (CPCP) website. Coordination with potential users will be an essential part of the transition of the technology.

It is the intent of the Project Management Plan (PMP) to implement this corrosion prevention and control technology at multiple regions and installations over the next 4 years, according to the schedule shown below. Where applicable, the UFGS, EIs, TIs, and TMs, including updates to existing guidance documents, developed for Army-wide implementation during the FY05 project, will be utilized to facilitate the planned implementation over the next 4 years.

FY	OSD Funds	HQ-IMA Matching	Planned Regions	Planned Installations
06	500	500	NWRO	Fort Carson
07	500	500	NWRO	Fort Riley
08	750	750	NERO	Watervliet Arsenal, West Point
09	500	500	NERO	Tobyhanna Army Depot

b. Potential ROI validation: Potential ROI will be validated by comparison of upgraded CP systems operational and maintenance requirements with ice-free CP, versus existing conventional CP systems using National Association of Corrosion Engineers (NACE) criteria. The calculated ROI for this project, which is based on current best practices, projected maintenance and rehab cost, has the potential to increase over the multiple year implementation due to reduction in down time, which will result in increased indirect savings. The ROI will be validated by an impartial NACE-certified Corrosion Expert such as John Fitzgerald (Past President of NACE) or similarly-qualified person suggested by NACE Headquarters.

c. Final Report: A final report will be written 60 days after the project is completed. The report will reflect the project plan format as implemented and will include lessons learned.

Projected Benefits:

Based on the past record of implementing these technologies at Army installations, reliable CP systems are projected to provide the benefits of restoring the water storage tanks to their optimum operating condition, as well as reducing maintenance, helping prevent water quality problems, and increasing safety. Corrosion inside the water tank

CORROSION PREVENTION AND CONTROL PROJECT PLAN
Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

can cause water quality problems (i.e., “red water”). Corrosion inside the water tank may also lead to corrosion of internal ladders that are used to inspect and service the water side of the tank. If left unmitigated, leaks and structural damage can occur. The ice-free CP system can reduce the likelihood of these occurrences.

Operational Readiness

All of the system components are commercially available and ready for implementation as solutions to the corrosion problems of the elevated potable water storage tanks at Fort Drum.

This technology will support the military mission by helping ensure that (1) aircraft deluge systems and other fire suppression systems are functioning properly and (2) safe, clean drinking water is readily available to fill portable tanks for soldiers who are deploying to arid regions.

Management Support

This project enjoys the support of the Fort Drum DPW Office, specifically, Mr. Tom Ferguson, Chief of the Operations and Maintenance Division. **Because of the urgency and importance of this work, Fort Drum is providing \$500K in matching funds.** IMA-NERO Region has also provided its support. Signatures have been obtained from representatives of Fort Drum DPW, IMA-NERO Region, HQ-IMA, HQ-ACSIM supporting this project, as shown on the coordination sheet. **See attached Memorandum from ACSIM Director for Facilities and Housing in Appendix 2.**

CORROSION PREVENTION AND CONTROL PROJECT PLAN
Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

COORDINATION SHEET

<u>ORGANIZATION</u>	<u>SIGNATURE</u>	<u>DATE</u>
Project Manager	See attached	_____
ERDC/CERL Branch Chief	See attached__	_____
Installation DPW POC	See attached__	_____
Installation Environmental POC	See attached__	_____
IMA Region	See attached__	_____
HQ IMA	See attached__	_____
HQ ACSIM	See attached__	_____
HQ AMC	Hilton Mills approved; signature is being sent under separate cover.	
Tri Service Facilities WIPT Chair	See attached__	_____

This is a TriService Project. Funds have been requested for Air Force and Navy representatives to participate in the evaluation of technology implementation.

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ARMY FACILITIES

CORROSION PREVENTION AND CONTROL PROJECT PLAN

Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

5. COORDINATION SHEET

ORGANIZATION

SIGNATURE

DATE

Project Manager

Vincent G. Pich

18 June 04

ERDC/CERL Branch Chief

Matt Flannery

6/18/04

Installation DPW POC

See Attached

Installation Environmental POC

See Attached

IMA Region

See Attached

HQ IMA

See Attached

HQ ACSIM

See Attached

HQ AMC

See Attached

Tri Service Facilities WIPT Chair

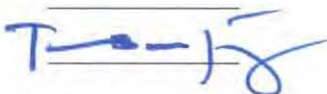
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ARMY FACILITIES

CORROSION PREVENTION AND CONTROL PROJECT PLAN

Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

6. COORDINATION SHEET

<u>ORGANIZATION</u>	<u>SIGNATURE</u>	<u>DATE</u>
Project Manager	_____	_____
ERDC/CERL Branch Chief	_____	_____
Installation DPW POC	_____	_____
Installation Environmental POC		_____
IMA Region	_____	_____
HQ IMA	_____	_____
HQ ACSIM	_____	_____
HQ AMC	_____	_____
Tri Service Facilities WIPT Chair	_____	_____

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ARMY FACILITIES

CORROSION PREVENTION AND CONTROL PROJECT PLAN

Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

6. COORDINATION SHEET

<u>ORGANIZATION</u>	<u>SIGNATURE</u>	<u>DATE</u>
Project Manager	_____	_____
ERDC/CERL Branch Chief	_____	_____
Installation DPW POC	_____	_____
Installation Environmental POC	_____	_____
IMA Region	<i>Bill Dancy</i>	<i>7/1/04</i>
HQ IMA	_____	_____
HQ ACSIM	_____	_____
HQ AMC	_____	_____
Tri Service Facilities WIPT Chair	_____	_____

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ARMY FACILITIES

CORROSION PREVENTION AND CONTROL PROJECT PLAN

Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

6. COORDINATION SHEET

<u>ORGANIZATION</u>	<u>SIGNATURE</u>	<u>DATE</u>
Project Manager	_____	_____
ERDC/CERL Branch Chief	_____	_____
Installation DPW POC	_____	_____
Installation Environmental POC	_____	_____
IMA Region	_____	_____
HQ IMA	_____	7/12/04
HQ ACSIM	_____	_____
HQ AMC	_____	_____
Tri Service Facilities WIPT Chair	_____	_____



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ARMY FACILITIES

CORROSION PREVENTION AND CONTROL PROJECT PLAN

Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

6. COORDINATION SHEET

<u>ORGANIZATION</u>	<u>SIGNATURE</u>	<u>DATE</u>
Project Manager	_____	_____
ERDC/CERL Branch Chief	_____	_____
Installation DPW POC	_____	_____
Installation Environmental POC	_____	_____
IMA Region	_____	_____
HQ IMA	_____	_____
HQ ACSIM		
HQ AMC	_____	_____
Tri Service Facilities WIPT Chair	_____	_____

This is a TriService Project. Funds have been requested for Air Force and Navy representatives to participate in the evaluation of technology implementation.

ARMY FACILITIES

CORROSION PREVENTION AND CONTROL PROJECT PLAN

Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

5. COORDINATION SHEET

ORGANIZATION

SIGNATURE

DATE

Project Manager

Vince T. Smith

18 June 04

ERDC/CERL Branch Chief

Mark Harris

6/18/04

Installation DPW POC

See Attached

Installation Environmental POC

See Attached

IMA Region

See Attached

HQ IMA

See Attached

HQ ACSIM

See Attached

HQ AMC

See Attached

Tri Service Facilities WIPT Chair

Howard Schuck

24 JUNE 2004

This is a TriService Project. Funds have been requested for Air Force and Navy representatives to participate in the evaluation of technology implementation.

CORROSION PREVENTION AND CONTROL PROJECT PLAN
Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

6. APPENDICES

Appendix 1. Potential ROI Calculations
Based on OMB Circular A94

Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

Assumptions:

Alternative 1: Due to the moderately corrosive water at Fort Drum, lack of cathodic protection in the two water storage tanks will result in extensive corrosion damage to the tanks, as well as distribution and deposition of corrosion products in the associated aged piping/equipment. The tanks and piping are projected to require replacement in year 10 at a cost of \$25.9M. The tanks would require replacement again in year 30 at a cost of \$1.5M. It is estimated that each unprotected tank would require an average of \$65K maintenance per year. Due to severe problems with poor water quality (i.e., “red water”), and tank shutdowns for emergency repairs, occupants would periodically require bottled water. The total bottled water requirement for one day would be 2 gallons/person x 20,000 people, or 40,000 gallons/day. At a cost of \$1/gallon, it would cost \$40,000 per day for the entire installation to use bottled water. Immediately after a tank replacement, bottled water would not be required. The need for bottled water would increase as the corrosion in the water storage tanks becomes more severe and the water quality deteriorates. A linear curve was used to estimate the consumption of bottled water, ranging from zero consumption (\$0) in the year of a tank replacement to 30 days (\$1,200,000) at the end of the tank’s life.

Alternative 2: Implementation of the Ice-Free Cathodic Protection Systems on two elevated water storage tanks at a cost of \$1,000K is projected to extend the life of the tanks and piping to the design life of 50 years; thus the tanks and piping would not require replacement. Tanks would require periodic maintenance at a cost of approximately \$40,000 per year. The ice-free CP systems would require replacement and the tanks would require major rehabilitation in years 15 and 30, at an estimated cost of \$400,000 per tank. Bottled water would generally not be required because proper water quality would be maintained; however to conservatively account for occasional repairs or problems, 3 days/year at a cost of \$120,000 is estimated.

Comparing the two alternatives, the potential return-on-investment for Alternative 2 is projected to be 20.55.

CORROSION PREVENTION AND CONTROL PROJECT PLAN
Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

Return on Investment Calculation

Investment Required

1,000,000

Return on Investment Ratio **20.55**

Percent **2055%**

Net Present Value of Costs and Benefits/Savings 2,380,432 22,935,014 **20,554,582**

A Future Year	B Baseline Costs	C Baseline Benefits/Savings	D New System Costs	E New System Benefits/Savings	F Present Value of Costs	G Present Value of Savings	H Total Present Value
1	65,000		160,000	720,000	149,536	733,661	584,125
2	65,000		160,000	780,000	139,744	738,023	598,279
3	65,000		160,000	840,000	130,608	738,752	608,144
4	65,000		160,000	900,000	122,064	736,199	614,135
5	65,000		160,000	960,000	114,080	730,825	616,745
6	65,000		160,000	1,020,000	106,608	722,936	616,328
7	65,000		160,000	1,080,000	99,632	712,992	613,360
8	65,000		160,000	1,140,000	93,120	701,310	608,190
9	65,000		160,000	1,200,000	87,024	688,034	601,010
10	25,965,000		160,000		81,328	13,198,010	13,116,682
11	65,000		160,000	60,000	76,016	59,388	-16,629
12	65,000		160,000	120,000	71,040	82,140	11,100
13	65,000		160,000	180,000	66,400	101,675	35,275
14	65,000		160,000	240,000	62,048	118,279	56,231
15	65,000		960,000	300,000	347,904	132,276	-215,628
16	65,000		160,000	360,000	54,192	143,948	89,756
17	65,000		160,000	420,000	50,656	153,551	102,895
18	65,000		160,000	480,000	47,344	161,266	113,922
19	65,000		160,000	540,000	44,240	167,283	123,043
20	65,000		160,000	600,000	41,344	171,836	130,492
21	65,000		160,000	660,000	38,640	175,088	136,448
22	65,000		160,000	720,000	36,112	177,175	141,063
23	65,000		160,000	780,000	33,744	178,211	144,467
24	65,000		160,000	840,000	31,536	178,376	146,840
25	65,000		160,000	900,000	29,472	177,753	148,281
26	65,000		160,000	960,000	27,552	176,505	148,953
27	65,000		160,000	1,020,000	25,744	174,577	148,833
28	65,000		160,000	1,080,000	24,064	172,208	148,144
29	65,000		160,000	1,140,000	22,496	169,423	146,927
30	1,565,000		960,000	1,200,000	126,144	363,321	237,177

CORROSION PREVENTION AND CONTROL PROJECT PLAN
Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

ROI Details

Old System Costs					New System Costs				
Year	O&M Costs			Cost Avoidance		Tank Maintenance	Tank Replace	Bottled Water	Total
	Tank Maintenance	Tank Replace	Total	Bottled Water					
1	65000		65000	720000		40000		120000	160000
2	65000		65000	780000		40000		120000	160000
3	65000		65000	840000		40000		120000	160000
4	65000		65000	900000		40000		120000	160000
5	65000		65000	960000		40000		120000	160000
6	65000		65000	1020000		40000		120000	160000
7	65000		65000	1080000		40000		120000	160000
8	65000		65000	1140000		40000		120000	160000
9	65000		65000	1200000		40000		120000	160000
10	65000	25900000	25965000	0	0	40000		120000	160000
11	65000		65000	60000		40000		120000	160000
12	65000		65000	120000		40000		120000	160000
13	65000		65000	180000		40000		120000	160000
14	65000		65000	240000		40000		120000	160000
15	65000		65000	300000		40000	800000	120000	960000
16	65000		65000	360000		40000		120000	160000
17	65000		65000	420000		40000		120000	160000
18	65000		65000	480000		40000		120000	160000
19	65000		65000	540000		40000		120000	160000
20	65000		65000	600000		40000		120000	160000
21	65000		65000	660000		40000		120000	160000
22	65000		65000	720000		40000		120000	160000
23	65000		65000	780000		40000		120000	160000
24	65000		65000	840000		40000		120000	160000
25	65000		65000	900000		40000		120000	160000
26	65000		65000	960000		40000		120000	160000
27	65000		65000	1020000		40000		120000	160000
28	65000		65000	1080000		40000		120000	160000
29	65000		65000	1140000		40000		120000	160000
30	65000	1500000	1565000	1200000		40000	800000	120000	960000

CORROSION PREVENTION AND CONTROL PROJECT PLAN
Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

APPENDIX 2

CORROSION PREVENTION AND CONTROL PROJECT PLAN
Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum



DEPARTMENT OF THE ARMY
ASSISTANT CHIEF OF STAFF FOR INSTALLATION MANAGEMENT
600 ARMY PENTAGON
WASHINGTON DC 20310-0600

3 MAR 2004

DAIM-FD

MEMORANDUM FOR DIRECTOR, INSTALLATION MANAGEMENT AGENCY, 2511
JEFFERSON DAVIS HIGHWAY, ARLINGTON VA 22202-3926

SUBJECT: FY 05 Army Corrosion Control Program

1. OSD has budgeted a total of \$27M in matching funds for implementation of corrosion prevention and control projects for equipment and facilities in FY 05. The Army's share for facilities is \$3.905M for the projects on the enclosed list. To take advantage of OSD's funding augmentation, HQ IMA will reserve \$3.905M to be released to ERDC-CERL upon confirmation by this office that OSD matching funds are available. Further instructions on the actual distribution of funds will follow at that time.

2. POC for this action is Mr. David N. Purcell, or (703) 601-0371,
David.Purcell@hqda.army.mil.

3. Quality Facilities for Quality Soldiers!

FOR THE ASSISTANT CHIEF OF STAFF FOR INSTALLATION MANAGEMENT

Encl


JOHN B. NERGER
Director, Facilities and Housing

CORROSION PREVENTION AND CONTROL PROJECT PLAN
Ice Free Cathodic Protection Systems for Water Storage Tanks at Fort Drum

FY05 Army Corrosion Prevention & Control Projects						
PROJECT TITLE	FY 05 Locations	Requested OSD Funds (\$000)	Matching HQ IMA Funds (\$000)	Installation Matching (\$000)	Total (\$000)	
Remote Monitoring of Cathodic Protection Systems	Redstone Arsenal, Ft. Hood, Ft. Drum, Ft. Shafter	\$490	\$490		\$980	
Corrosion Resistant Materials	Ft. Bragg, Ft. Drum, Ft. Lee, Ft. Irwin	\$530	\$530		\$1,060	
Leak Detection for Pipes and Tanks	Ft. Campbell, Ft. Hood, APG, Ft. Carson, Ft. Shafter	\$250	\$250		\$500	
Non-hazardous Corrosion Inhibitors/SMART Control Systems for Heating & Cooling	Ft. Carson, Ft. Stewart, Ft. Hood, Ft. Richardson, Ft. Shafter, Ft. Riley	\$1,300	\$1,300		\$2,600	
Innovative Corrosion Resistant Materials/Indicator Coatings for High Temp/Steam Piping	Ft. Jackson, West Point, Ft. Riley, Ft. McCoy	\$240	\$240		\$480	
Surface Tolerant Coatings	Ft. Campbell, Hunter Army Airfield, Ft. Hood, Ft. Carson	\$420	\$420		\$840	
Electro-Osmotic Pulse Technology	Ft. Bragg, Ft. Drum, Ft. Carson, Ft. Shafter, Ft. Sill, Ft. Jackson	\$325	\$325		\$650	
In-situ Pipe Coating Technology	Ft. Drum, Ft. Jackson, Ft. Carson, Ft. Lewis, Ft. Hood, Ft. Richardson, Ft. Shafter	\$250	\$250		\$500	
Pipe/Tank Corrosion Sensors	Ft. Campbell	\$100	\$100		\$200	
Sub-Total For IMA Matching		\$3,905	\$3,905		\$7,810	
Cathodic Protection of Hot Water Tanks Using Ceramic Anodes (Ft. Sill on-going)	Ft. Sill	\$500		\$1,100	\$1,600	
Ice Free Cathodic Protection Systems for Water Storage Tanks (Ft. Drum on-going)	Ft. Drum	\$500		\$500	\$1,000	
TOTAL FY 05 Program		\$4,905	\$3,905	\$1,600	\$10,410	

ENCL

Appendix B: Contractor Planning and Safety Documents

Draft 3 (August 25, 2005)

Work Plan

AR-F-318: Ice-Free Cathodic Protection (CP) Systems at Fort Drum, NY

1.0 Background:

The objectives of this project are to (1) design and install ice-free cathodic protection (CP) systems using ceramic-coated anodes in two (2) elevated storage tanks at Fort Drum, NY; and (2) monitor their performance by furnishing and installing water chemistry and corrosion-rate measurement equipment at selected locations, interfaced to the existing SCADA system at Fort Drum. The cost savings achieved by this approach will be documented.

The water-chemistry sensor, known as "PipeSonde In-Pipe Probe", is manufactured by HACH Company (Loveland, CO); it is a multiparameter instrument that automatically measures pH, conductivity, turbidity, dissolved oxygen (or chlorine), oxidation-reduction potential (ORP), pressure, and temperature continuously. Two types of corrosion-rate sensors, both manufactured by Rohrback Cosasco Systems (Santa Fe Springs, CA), will be used to measure corrosion rates automatically. The "Corrater", which utilizes the linear polarization resistance (LPR) technique, will measure instantaneous corrosion rates in the water. The "Corrosometer", which uses the electrical resistance (ER) technique, will measure efficacy of cathodic protection in controlling corrosion of submerged areas on the tank interior.

The following work-plan is proposed by Bushman & Associates' (B&A) pertaining to the aforementioned objectives.

2.0 CP System Design:

Ice-free impressed CP systems will be designed to protect the interior surfaces (below the waterline) of the two elevated tanks located at Ft Drum, NY. The systems shall utilize commercially available ceramic-coated wire anodes attached to a tethered flotation device that prevents it from contacting the ice. The data acquisition system for monitoring the CP system performance will be designed to include "instant off" potential measurements. The draft designs will be reviewed by the Government CP system and data acquisition design changes, as necessary, will be made and the final designs submitted by end August, 2005.

3.0 Initial Site visit:

B&A made an initial site visit to Fort Drum, NY, July 12 – 13, 2005, and participated in two pre-work conferences. A list of attendees is appended to this work plan. Vicki Van Blaricum provided an overview of the project. The primary objective is to install ice-free cathodic protection systems in two (2), 1-million gallon each, elevated, potable water-storage steel tanks and demonstrate that corrosion is being mitigated on the tank interior below the waterline. A secondary objective is to monitor water corrosivity by installing commercial water-chemistry and corrosion-rate sensors at a number of locations in the potable water system at Ft. Drum.

During the July 12 meeting, B&A described the data necessary for design and specification of ice-free impressed current cathodic protection (CP) systems to protect the interior surfaces of two elevated water-storage tanks. Suitable locations for hardware installation were discussed and visits made on the same day (July 12) to the following seven (7) candidate sites at Ft. Drum.

(i) Tank #3

Photos #1338 shows an exterior view of tank #3, which was reportedly constructed in 1986 and has a CP system [W&T 30V 20A Micropolatrol transformer-rectifier (T/R); system No. 16821; model No. 687 – Photo #1349]. The T/R display panel indicated voltage and current as 3.1V and 0.1A, respectively; with an apparent set-point potential of -0.98V. When the new ice-free cathodic protection system is installed by B&A, a new T/R will be installed to replace the existing one. Tank #1 is under construction. The tank construction drawings were reviewed. Ft. Drum personnel indicated that the water level in the tank could fluctuate over a 70 – 91 foot maximum range; however, levels in the summer were more typically in the 85 – 91 foot range. B&A will install a Corrosometer (ER) probe in the tank through an access fitting installed through the dry access tube approximately 3' above the bottom of the tank bowl. This access fitting is to be furnished by a Ft. Drum contractor. For further information, see Photos 1338 through 1350.

Photo #1342 shows a view of the insulated and electrically-heated circa 20-inch diameter riser pipe at the base of the tank. This represents a possible location for installation of one water-chemistry and one corrosion-rate sensor, through suitable access fittings to be furnished by a Ft. Drum contractor. Since the riser is vertical, any sensor probes installed here would likely be oriented horizontally.

The potential of the tank under CP, associated current, and outputs of the water-chemistry and corrosion-rate sensors will be interfaced to the existing Bristol Babcock Supervisory Control and Data Acquisition (SCADA) system at Ft. Drum. The SCADA system for this tank is located in the “doghouse” at the base of the tank. The SCADA system is capable of collecting data to validate that (i) the CP system is operating properly and continuously, and (ii) corrosion is not occurring inside the tank. The system will also be

capable of monitoring water quality and corrosion rate at the candidate locations in the water system.

(ii) Tank #1

This tank is presently under construction and expected to be completed sometime in late summer (Photo #1373). The US Army Corps of Engineers and the tank contractor participated in the discussions about CP system hardware and installation requirements. B&A anticipates installing the ice-free CP systems in both tanks in September/October and commence acquiring data as soon after both tanks are commissioned. The hardware and monitoring requirements will be similar to those described above for tank #3. See B&A Drawing Numbers SKCH-2405-1 through 2405-3 provided in MS Powerpoint File format ("Tank Entrance Fittings and Suspension Brackets. ppt") attached to this work plan.

(iii) Vault #4 (Conway Road)

Photos 1308 through 1321 show the water pipe system in vault #4. This is a candidate location for a water-chemistry and a corrosion-rate sensor. The sensor probes can be installed in the 16-inch diameter steel pipe, where inlet and outlet pressures are nominally 100 psi and 50 psi, respectively. A local contractor will hot tap the pipe; it appears that pipe saddles may not be necessary. The SCADA system is shown in Figure __.

(iv) Vault #3 (4th Street)

Photos 1324 through 1335 show the water pipe system in vault #3. This is another candidate location for a water-chemistry and a corrosion-rate sensor. The sensor probes can be installed in the 16-inch diameter ductile iron pipe, where inlet and outlet pressures are nominally 100 psi and 50 psi, respectively. A local contractor will hot tap the pipe; since the pipe has existing access fittings, it appears that pipe saddles may be unnecessary. The SCADA system is shown in Figure __.

(v) DANC (Development Area of the North Country)

Photos 1352 through 1372 show a possible site for installation of the water-chemistry and corrosion-rate sensors, upstream of the discharge header. Two existing access fittings indicate that hot tapping for the sensor probes can be done (by a local contractor) and saddles may not be necessary. The SCADA system is shown in Figure __.

(vi) Ground Reservoir (Leray Drive)

Photos 1375 through 1384 show a possible site for installation of the water-chemistry and corrosion-rate sensors. This pipe spool is 6-inch diameter. Ft. Drum personnel agreed to replace it with a new pipe spool, 8-inch diameter, the minimum size recommended by the sensor probe manufacturers. Hot tapping for the sensor probes will be done (by a local

contractor) and it appears that saddles may be unnecessary. The SCADA system is shown in Photo 1384.

(vii) New Water Treatment Plant

This plant is presently under construction. This represents a possible seventh site for water-chemistry and corrosion-rate sensor installation. Reference Drawings shown in Photos 1385 through 1389

For review of the photos, thumbnail prints of each photo taken on site have been attached to this work plan in PDF format. A CD of these photos in full resolution is also provided with this work plan for detailed review.

4.0 Acquisition of CP hardware and Sensors:

Immediately after the work plan detailed in this document is approved, purchase orders will be placed for the two (2) CP anode assemblies and tethered floatation devices, two (2) impressed current transformer-rectifiers, five (5) PipeSonde water-chemistry sensor probes, five (5) Corratel corrosion-rate sensor probes, and two (2) Corrosometer (ER) sensor probes with their respective manufacturers. The anticipated delivery times are 4-6 weeks after ordering. The CP hardware and sensors will be delivered directly to the designated POC at Ft. Drum where they will be inspected by B&A prior to installation.

5.0 CP Hardware and Sensor Installation:

The target time frame for installation of the CP anodes, transformer-rectifiers, and sensors at Ft. Drum is September/October, 2005. However, before the sensors can be installed, the selected monitoring locations will need to be hot-tapped. Hot-tapping, which consists of providing access into the pipe or tank interior without interruption of water flow, will be performed by a qualified local plumbing contractor and paid for by CERL. It is understood that others will furnish and install hot taps with saddles and **2-inch ball valves** for the water-chemistry (HACH) probes; and **1-inch ball valves** for the corrosion-rate (Corratel) probes; and one (1) tap into each storage tank below the icing zone for insertion of the ER (Corrosometer) probes. Location of the taps will have to be coordinated with the sensor manufacturers and B&A to ensure correct size and orientation for insertion and operation of the probes.

According to the manufacturer, the water-chemistry sensor should be mounted at a clock position between 70° and 20° with respect to the top of the pipe (which is 12 o'clock) to minimize risk of air-bubble entrapment under the sensing elements' protective shield. The corrosion-rate and ER sensors can be mounted at any angle. However, it is essential that all sensor elements be completely immersed in the water at all times.

The first set of sensors will be installed with the designated Ft. Drum personnel and at least the water-chemistry sensor manufacturer's representative present on site. The remaining sensor sets will be installed by B&A (through pre-furnished valves, as

discussed above) with oversight by the designated Ft. Drum personnel. The corrosion sensor electrodes (carbon steel alloy UNS K03005; supplied by the sensor manufacturer) will be degreased and weighed individually to a precision of ± 0.1 mg before being mounted on the corrosion-rate probes. The location of each electrode on the probe will be noted. Each probe will consist of 3 electrodes; i.e. 2 for performing the linear-polarization resistance measurements (from which instantaneous, on-line corrosion rate is determined) and 1 freely-corroding, unpolarized, control “electrode”. The ER-probe sensing element will be carbon steel and electrically “grounded” to the tank so that the sensing element is also under the influence of cathodic protection from the tank anodes.

6.0 CP System, Sensor, Wiring and Data Acquisition System Wiring:

The wiring for the CP system will be performed by B&A with assistance from designated Ft. Drum personnel. The latter will also insure that a reliable 120V, 60 Hz, 1 Phase AC or 24V supply is available for powering the sensors before they are installed. The total current requirements for the sensors at each location, including data acquisition, measurement will be less than 1 amp. Appropriate metallic conduit and signal wiring will also be furnished by Ft. Drum to protect the wiring between the sensors and the SCADA system, as well as for the power supply.

The sensors will be connected to a Bristol & Babcock Supervisory Control and Data Acquisition (SCADA) System at Ft Drum. The SCADA system shall be capable of monitoring CP T/R voltage (0-50V DC), current (0-30A DC), and structure potential (0-2V DC), water-chemistry sensor MODBUS output, and corrosion-rate (Corrosometer ER and Corrater LPR) sensors, each 4-20 mA outputs.

The sensors will be checked for calibration periodically. The water-chemistry sensor uses several manufacturer-supplied “standard” solutions for calibration checks. The corrosion-rate and ER sensors use manufacturer-supplied solid-state “dummy” cells for calibration.

7.0 Data Acquisition and Analysis:

Data acquisition and analysis will be performed for a minimum of 7 months to document the CP system operation, corrosion rates, and water chemistry (corrosivity).

The cathodic protection system performance will be assessed in two ways. First, “ON” potential and “instant OFF” potential measurements, using a silver/silver-chloride/Saturated KCl Reference electrode (half cell), a digital voltmeter, and a current interrupter switch. The “ON” measurements will be made periodically, e.g. every 15 minutes, via the SCADA system. The “instant OFF” potential measurements, to correct for ohmic-drop errors, only need to be made occasionally, e.g. every 2 months; designated Ft Drum personnel would be instructed to make these measurements. The

second method to assess CP system performance will involve analyzing the output of the ER (Corrosometer) probe as discussed below.

All the parameters of the water-chemistry (PipeSonde) sensor are monitored simultaneously and continuously. The output is MODBUS via 2 wires, which would be interfaced to the SCADA system. The manufacturer recommends data collection by the SCADA system at 15-minute intervals. For the corrosion-rate (Corrater) and ER (Corrosometer) sensors, the 4-20 mA outputs will be interfaced to the SCADA system; this manufacturer also recommends data collection every 15 minutes. The data collection frequencies can be modified if so warranted after review of the initial data obtained, e.g. during the first 2 weeks. Designated personnel at Ft Drum will collect the data and send it to B&A on CD-ROM discs at regular intervals, e.g. every two weeks, as Microsoft EXCEL spreadsheets. B&A will analyze the data, graph it as necessary, and distribute it to designated personnel in monthly status reports.

Data analysis will consist of reviewing and comparing the data collected from the water-chemistry sensors and corrosion-rate and ER sensors to determine variations in the parameters measured and correlations between the data from the sensors at each location. Data will be compared to “grab” water sample analysis, which will be conducted periodically by CERL. At the conclusion of the testing, the corrosion-rate sensor electrodes will be examined, photographed, cleaned carefully to remove corrosion products, dried, and reweighed to a precision of ± 0.1 mg and the corrosion rate calculated from mass loss. This will be compared with the integrated corrosion-rate versus time data obtained from the sensor (linear polarization resistance) measurements made previously on the same electrodes. Data from the third, freely-corroding, unpolarized, control “electrode” will represent an independent “calibration” check for the pair of corrosion-rate measuring electrodes. Data from the ER sensor will be used to determine the effectiveness of the cathodic protection system in controlling corrosion on the tank interior (below the water-line). This will involve monitoring any changes in the sensor output and hence increase in electrical resistance. No detectable change in output would indicate that CP has effectively mitigated corrosion of the tank wall to a negligible level.

8.0 Reporting:

B&A will submit electronic monthly progress reports (one copy) in Microsoft Word, via e-mail to SKT with copies to the CERL’s technical POC. The reports will document progress made during the preceding month, summary of any data collected and analyzed, outline plans for the next reporting period, recommend any changes in water treatment and ice-free CP system settings; or other modifications to improve corrosion mitigation in the water system if corrosion is indicated.

The CP systems will be inspected physically after they have been in service for one (1) winter season to verify and document the condition of the steel tank and CP hardware, i.e. anodes, transformer-rectifier, and tethered flotation devices. The results will be reported in the pertinent monthly status report.

In addition B&A will submit the following reports for Government review:

- (i) One electronic copy of the draft training materials (within 12 months of contract award)
- (ii) One electronic copy of the draft guide specification and other design, operation and guidance (within 14 months of contract award)
- (iii) One electronic copy of the final Unified Facilities Guide Specification and other design, operation and guidance incorporating the Government's comments (within 15 months of contract award)
- (iv) One electronic copy of a draft report documenting the results of all the tasks (within 15 months of contract award)
- (v) One electronic copy of a final report documenting the results of all work incorporating Government comments (within 16 months of contract award). This will include data and documentation of cost savings and return on investment (ROI) using OMB Circular A-94 methods. Potential ROI will be validated by comparison of upgraded CP systems' operational and maintenance requirements with ice-free CP, versus existing conventional CP systems. An impartial NACE-certified corrosion expert will validate the ROI.

9.0 Meetings:

B&A will participate in a maximum of five (5) meetings at Ft Drum and a maximum of three (3) meetings at ERDC-CERL in Champaign, IL, during the course of this project. This includes a one-day final wrap-up meeting at CERL in Champaign, IL, at the conclusion of the project. A number of the tasks will be consolidated and performed during any given visit; in other words, each task will not require a separate trip.

Appendix 1

Personnel present at two meetings held during the visit to Ft. Drum, NY, July 12-13, 2005. Contact phone numbers shown in parenthesis.

July 12, 2005 Meeting :

Vicki Van Blaricum – General Engineer/Project Manager, CERL (217-373-6771); Vicki.L.VanBlaricum@erdc.usace.army.mil

James Bushman – President, Bushman & Associates (330-310-9099); james@bushman.cc

Bopinder Phull – Corrosion Consultant, subcontractor to Bushman & Associates (910-686-2516); bop@cormat.com

Tom Ferguson – O&M Chief, Ft. Drum (315-772-4947); ferguson@drum.army.mil

Frank Coburn – Ft. Drum (315-523-1327)

Ed Rohr – Utilities, Bldg 4004, Ft. Drum (315-772-9541); (315-523-1313)

Paul Fish – O&M, Bldg T-4000, Ft. Drum (315-772-3322); paul.s.fish@us.army.mil

July 13, 2005 Meeting :

Vicki Van Blaricum – General Engineer/Project Manager, CERL (217-373-6771); Vicki.L.VanBlaricum@erdc.usace.army.mil

James Bushman – President, Bushman & Associates (330-310-9099); james@bushman.cc

Bopinder Phull – Corrosion Consultant, subcontractor to Bushman & Associates (910-686-2516); bop@cormat.com

Tom Ferguson – O&M Chief, Ft. Drum (315-772-4947); ferguson@drum.army.mil

Ed Rohr – Utilities, Bldg 4004, Ft. Drum (315-772-9541); (315-523-1313)

David Carr – PW Eng. Div. Ft. Drum (716-655-3433); david.james.carr@us.army.mil

Larry Rosenkranz – USACE, Ft. Drum Resident Office (315-773-7502); larry.m.rosenkranz@usace.army.mil

John Kucirck – PM, Clark Construction (315-773-5874); john.kucirck@clarkconstruction.com

Jim Moore – J. L. Moore, Inc. East Aurora, NY (716-655-3433); jmoore@jlmoore.net

Draft 3 (August 25, 2005)

Data Collection Plan

AR-F-318: Ice-Free Cathodic Protection Systems at Fort Drum, NY

1.0 Background:

The objectives of this project are to (1) design and install ice-free cathodic protection (CP) systems using ceramic-coated anodes in two (2) elevated storage tanks at Fort Drum, NY; and (2) monitor their performance by furnishing and installing water chemistry and corrosion-rate measurement equipment at seven (7) locations, interfaced to the existing SCADA system at Fort Drum. The cost savings achieved by this approach will be documented. Reportedly, one of the tanks exists and the other one is under construction.

The water-chemistry sensor, known as "PipeSonde In-Pipe Probe", is manufactured by HACH Company (Loveland, CO); it is a multiparameter instrument that automatically measures pH, conductivity, turbidity, dissolved oxygen (or chlorine), oxidation-reduction potential (ORP), pressure, and temperature continuously. Two types of corrosion-rate sensors, both manufactured by Rohrback Cosasco Systems (Santa Fe Springs, CA), will be used to measure corrosion rates automatically. The "Corrater", which utilizes the linear polarization resistance (LPR) technique, will measure instantaneous corrosion rates in the water. The "Corrosometer", which uses the electrical resistance (ER) technique, will measure efficacy of cathodic protection in controlling corrosion of submerged areas on the tank interior.

The following data collection plan is proposed by Bushman & Associates (B&A) for this project.

2.0 Data Collection

The Bristol Babcock Supervisory Control And Advisory Data Acquisition (SCADA) system at Ft. Drum will be used for collecting data to validate that (i) the CP systems are operating properly and continuously, and (ii) corrosion is not occurring inside the tank (i.e. below the waterline). The CP system operation and performance will be determined by measurement of "ON" potential (e.g. every 15 minutes) and "instant OFF" potentials (e.g. every 2 months), using silver/silver-chloride/saturated reference electrode (half cell), digital voltmeter, and interrupter switch. Data will also be collected from two (2) electrical resistance (RCS, Corrosometer) sensors every 15 minutes to verify mitigation of tank corrosion (internally below the waterline) by the CP systems. These sensors have

4-20 mA, real-time, continuous outputs. The sensors manufacturer suggests a data collection frequency of once every 15 minutes by the SCADA system. After review of initial data (e.g. first week) by all interested parties, this frequency of data collection can be changed if necessary.

In addition, data will be collected from eight (8) water-chemistry (HACH, PipeSonde) and six (6) corrosion-rate (RCS, Corratec) sensors to monitor corrosivity and hence effectiveness and optimization of treatment in the water system. Each sensor will have a 2-wire output. The water-chemistry sensor output will be MODBUS; and the corrosion-rate sensor output will be 4-20 mA. Both sensors have real-time, continuous outputs. Manufacturers of both sensors have suggested a data collection frequency of once every 15 minutes by the SCADA system. After review of initial data (e.g. first week) by all interested parties, this frequency of data collection can be changed if necessary.

3.0 Data Transmission

The data collected by the SCADA system will be downloaded to a disc in Microsoft EXCEL spreadsheet format and transmitted to B&A every 2 weeks by designated Ft Drum personnel. B&A will review the data, graph it as necessary and transmit it to the client, CERL (POC, Vicki Van Blaricum), in monthly status reports. As agreed, the data will be shared with the designated Ft. Drum personnel as well as the sensor manufacturers for review and comment.

Draft_3 (August 25, 2005)

Communications Plan

AR-F-318: Ice-Free Cathodic Protection Systems at Fort Drum, NY

1.0 Background:

The objectives of this project are to (1) design and install ice-free cathodic protection systems using ceramic-coated anodes in two (2) elevated storage tanks at Fort Drum, NY; and (2) monitor their performance by furnishing and installing water chemistry and corrosion-rate measurement equipment at eight (8) locations, interfaced to the existing SCADA system at Fort Drum. The cost savings achieved by this approach will be documented.

The water-chemistry sensor, known as "PipeSonde In-Pipe Probe", is manufactured by HACH Company (Loveland, CO); it is a multiparameter instrument that automatically measures pH, conductivity, turbidity, dissolved oxygen (or chlorine), oxidation-reduction potential (ORP), pressure, and temperature continuously. Two types of corrosion-rate sensors, both manufactured by Rohrback Cosasco Systems (Santa Fe Springs, CA), will be used to measure corrosion rates automatically. The "Corrater", which utilizes the linear polarization resistance (LPR) technique, will measure instantaneous corrosion rates in the water. The "Corrosometer", which uses the electrical resistance (ER) technique, will measure efficacy of cathodic protection in controlling corrosion of submerged areas on the tank interior.

The following is Bushman & Associates' (B&A) communications plan for this project

Primary Client contact:

Bushman & Associates, Inc. (B&A) primary contact will be with Ms. Vicki VanBlaricum [Office: (217) 373-6771], Project Manager (CERL). All contractual matters will be directed to her for handling. At Ft. Drum, our primary contact will be Tom Ferguson (315-772-4947). All communications dealing with scheduling and work activities will be routed through her and/or her designated Plant Managers. A monthly activities report will be prepared and sent to Ms. Vicki VanBlaricum at the first of each month until the project is completed, with a copy being sent to Vincent Hock at CERL.

All communications dealing with this project from interested parties outside of B&A should be directed to James B. Bushman as the Contractor Representative or to Vincent Hock or Vicki VanBlaricum as the COTRs at US Army CERL in Champaign, IL

Primary contractor contact:

James B. Bushman, Project Administrator and Officer for B&A
PO Box 425
Medina, OH 44258

Shipping Address:
6395 Kennard Road
Medina, OH 44256

Phone Office: 330-769-3694
Phone Cell: 330-310-9099
Fax: 330-769-2197
Email: james@bushman.cc

Alternate contact:

Dr. Bopinder S. Phull, Project Manager and Corrosion Consultant (sub-contractor to B&A)
308 Humphrey Drive
Wilmington, NC 28411

Phone Office: (910) 686-2516
Phone Cell: (910) 352-9030
Fax: (910) 686-2516
Email: Bop@cormat.com

DRAFT 3 (August 25, 2005)

ACCIDENT PREVENTION PLAN

Ft. Drum, NY

Prepared By:
Bushman & Associates, Inc.
Medina, OH 44256

July 24, 2005

ACCIDENT PREVENTION PLAN

This document represents Bushman & Associates' (B&A) Accident Prevention Plan. It is supplemented with B&A's Policies and Procedures Manual, which is under separate cover. This plan is submitted in outline form and follows Document No. EM 385-1-1, dated 3 Nov 03, which was provided by the US Army Corp of Engineers.

1) **Signature Sheet:**

- a) The plan was prepared by James B. Bushman who is President of Bushman & Associates, Inc. and is authorized by B&A's management which is evidenced by the signature of James B. Bushman, President shown below:



James B. Bushman, President

2) **Background Information:**

- a) Contractor: Bushman & Associates, Inc.
- b) Contract Number: 5014-BUSH-003
- c) Project Name: Furnish & Install Corrosion Sensors at Ft. Drum, NC
- d) Project Description: The objective is to install three (3) each pipe corrosion rate and water chemistry sensors in 3 critical areas of the water distribution system at Fort Drum (6 sensors total), to evaluate their accuracy and performance and their synergistic capabilities for evaluating effectiveness of any corrosion mitigation procedures used.
- e) B&A's EMR is 1.08.
- f) B&A knows of no AHA implications on this job.

3) **Statement of Safety and Health Policy:** B&A's Policies and Procedures Manual is provided under separate cover.

4) **Responsibilities and Lines of Authorities:**

- a) James B. Bushman is responsible for the identification and accountability of the APP at the corporate level. Dr. Bopinder S. Phull is responsible for the identification and accountability of the APP at the project level.
- b) The reporting and authority sequence is as follows: James B. Bushman – President, Dr. Bopinder S. Phull, Project Manager, Sub-Contractor Project Manager.

5) **Subcontractors and Suppliers:**

- a) The sub-contractors that will be used on this job are:
 - i) Hach Company, of 5600 Lindbergh Drive, Loveland, Colorado 80539 -- Water Chemistry Sensor Technology Sub-contractor
 - ii) Rohrback Cosasco Systems, 11841 E. Smith Avenue, Santa Fe Springs, CA 90670 – Corrosion Rate Measurement Instrumentation Sub-contractor
 - iii) MSE Technology Applications, Inc., 103A Sleepy Drive, Spring Lake, NC 28390 – SCADA Communications Systems Sub-contractor

- b) B&A will control all sub-contractors along with their respective construction managers. Subcontractors will be required to follow all procedures previously agreed with B&A; any deviations/modifications will require approval by B&A.
 - c) All sub-contractors will be responsible for their own personnel's safety, including conducting weekly safety meetings.
- 6) **Training**
- a) The following subjects will be discussed with employees in their safety indoctrination:
 - i) Housekeeping at Ft. Drum
 - ii) Contractor equipment handling and storage while at Ft. Drum
 - iii) Ft. Drum's Management
 - iv) Ft. Drum's Health and Safety Facilities
 - v) Project Scope
 - b) There are no mandatory training and/or certifications that are applicable to this project.
 - c) There is no emergency response training that is required by this project.
 - d) The initial safety meeting will be conducted by either Dr. Bopinder Phull, Project Manager for B&A or James B. Bushman, President, B&A. All subsequent safety meetings will be conducted by the Dr. Bopinder Phull, Project Manager in conjunction with each subcontractor's project manager involved with the project.
- 7) **Safety and Health Inspections:**
- a) The Project Manager for B&A will conduct routine safety inspections when visiting the job site at Ft. Drum and record them in the project notebook.
 - b) There are no external inspections/certifications that are required by this project.
- 8) **Safety and Health Expectations, Incentive Programs, and Compliance**
- a) B&A's Policies and Procedures Manual is provided.
 - b) B&A does not have a Safety incentive program.
 - c) This is included in item "a" above.
 - d) This is included in item "a" above.
- 9) **Accident Reporting:**
- a) Exposure Data: Man-hours worked will be collected by B&A's Project Manager, and sent weekly to James B. Bushman who will in turn include the information in B&A's Monthly Report which will be prepared by Dr. Phull and reviewed by Mr. Bushman.
 - b) Accident Investigations, reports and logs: This information will be collected by B&A's Project Manager. It will be sent weekly to James B. Bushman who will in turn include the information in B&A's Monthly Report, which will be prepared by Dr. Phull and reviewed by Mr. Bushman.
 - c) Immediate notification of major accidents: In the event of a major accident, ????????? (Fort Drum Person) will be immediately notified along with any appropriate governing agency. After the fact, this information will also be communicated to Tom Ferguson, O & M Chief, Ft. Drum and James B. Bushman with B&A.
- 10) **Medical Support:** B&A and their sub-contractors will provide their own first aid services on job site. For life threatening and/or serious injury, it is our understanding that we may use the emergency services of the Ft. Drum Hospital. The Construction

Manager for each company is responsible for seeing that medical support is available for his employees.

- 11) **Personal Protective Equipment:** The Construction Manager for each company involved with this project is responsible for their employee's PPE. This is to include but not limited to hard hats, safety glasses, gloves, hearing protection, safety shoes, body harnesses, and lanyards. B&A's Project Manager will submit a weekly written report to James B. Bushman stating that they verified that each employee was in possession and was using their PPE. These reports will be attached to the Monthly Reports.

12) Plans (Programs, Procedures) Required by the Safety Manual:

- a) Layout plans: There are none associated with this project.
- b) Emergency response plans: There are none associated with this project.
 - i) Procedures and tests: There are none associated with this project.
 - ii) Spill plans: There are none associated with this project.
 - iii) Firefighting plan: There is none associated with this project.
 - iv) Posting of emergency telephone numbers: A list of Ft. Drum and local telephone numbers will be printed and provided to the construction Managers associated with this project.
 - v) Wild land fire prevention plan: There is none associated with this project.
 - vi) Man overboard/abandon ship: There is none associated with this project.
- c) Hazard communication program : While no hazardous materials are planned for use on this project, if such is incorporated into the project, B&A's Project Manager will maintain MSDS sheets for any and all hazardous material brought on site. This is to include an inventory of those items along with the amounts of each item brought to Ft. Drum . If a product requires special training, the Construction Manager who is responsible for that product(s) will have in his possession copies of the appropriate employee training certificates involved with handling the product(s).
- d) Respiratory protection plan: There is none associated with this project.
- e) Health hazard control program: There is none associated with this project.
- f) Lead abatement plan: There is none associated with this project.
- g) Asbestos abatement plan: There is none associated with this project.
- h) Abrasive blasting: There is none associated with this project.
- i) Confined space: There is none associated with this project.
- j) Hazardous energy control plan: There is none associated with this project.
- k) Critical lift procedures: There are none associated with this project.
- l) Contingency plan for severe weather: Outside work activities will cease in the presence of high winds, heavy rain and/or lightning. Work activities will not resume until conditions are favorable.
- m) Access and haul road plan: There is none associated with this project.
- n) Demolition plan: There is none associated with this project.
- o) Emergency rescue (tunneling): There is none associated with this project.
- p) Underground construction fire prevention and protection plan: There is none associated with this project.
- q) Compressed air plan: There is none associated with this project.

- r) Formwork and shoring erection and removal plans: There are none associated with this project.
 - s) Jacking plan (lift) slab plans: There are none associated with this project.
 - t) Safety and health plan: Please refer to B&A's Policies and Procedures Manual.
 - u) Blasting plan: There is none associated with this project.
 - v) Diving plan: There is none associated with this project.
 - w) Plan for prevention of alcohol and drug abuse: There is none associated with this project.
 - x) Fall protection plan: There is none associated with this project.
 - y) Steel erection plan: There is none associated with this project.
 - z) Night operations plan: There is none associated with this project.
 - aa) Site sanitation plan: All subcontractor crews are very small, with the largest being four people. It is our plan to use either the sanitation facilities at Ft. Drum or use available facilities off post.
 - bb) Fire Prevention plan: All contractor and sub-contractor trucks will have fire extinguishers in them.
- 13) **Contractor Information:** B&A will provide a Monthly Report, which will address and provide the information required that the requirements of the APP are being met. The distribution of this report will be to Marcia Meekins, Brenda Audette and Dave Stephenson.
- 14) **Site-Specific hazards and Controls:** There are none associated with this project.

B&A HEALTH & SAFETY MANUAL

Ver. 4.0



BUSHMAN & Associates, Inc.

C O R R O S I O N C O N S U L T A N T S

P.O. Box 425, Medina, OH 44258 • Phone 330/769-3694, Fax 330/769-2197

Website: www.bushman.cc

Bushman & Associates Health and Safety Manual

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GENERAL INFORMATION

OVERVIEW

Industrial injury accidents create a no-win situation for everyone involved. Employees experience pain, suffering and incapacitation while the company suffers from the loss of the injured person's contributions. This document provides information and guidance for the establishment and maintenance of an accident-free work environment.

PROCEDURES

The appendixes to this directive contain guidance for safety procedures to be followed, and forms to be used. Supervisors are expected to integrate the procedures into the appropriate work activity and employees are expected to apply them on the job. The sample forms are to be used if they apply to the job concerned.

A copy of this statement will be issued to all supervisory and management personnel. A copy of the policy statement will give to each employee.

REGULATIONS

A copy of the following documents will be maintained on each job site:

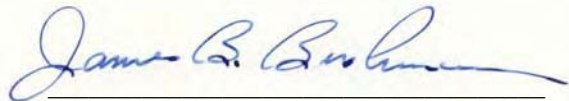
- ◆ Bushman & Associates Safety Manual
- ◆ OSHA Safety and Health Standards (29 CFR 1926 - Construction and 29 CFR 1910 - General Industry)

SAFETY AND HEALTH POLICY

The purpose of this policy is to develop a high standard of safety throughout all operations of Bushman & Associates and to provide guidelines so employees are not required to work under conditions that are hazardous or unsanitary.

Employees have the right to derive personal satisfaction from their jobs. The prevention of occupational injury or illness is central to this belief that it will be given top priority at all times.

It is Bushman & Associates's goal to initiate and maintain complete accident prevention and safety training programs. Each individual is responsible for the safety and health of those persons in their charge and co-workers around them. By accepting mutual responsibility to operate safely, we will all contribute to the well being of personnel.



James B. Bushman, President

SAFETY AND HEALTH RESPONSIBILITIES

Responsibility for safety and health include the establishment and maintenance of an effective communication system between workers, supervisors and management. To this end, all personnel are responsible to make sure that their messages are received and understood by the intended receiver. Specific safety and health responsibilities for personnel are as follows:

MANAGEMENT OFFICIALS:

Active participation in and support of safety and health programs is essential. Managers will display interest in safety and health matters. At least one manager (as designated) will participate in project safety and health meetings, accident investigations and job site inspections. Each manager will establish realistic goals for accident reduction in his/her area of responsibility and will establish the necessary implementing instructions for meeting the goals. Goals and implementing instructions shall be within the framework established by this document.

SUPERVISORS:

The safety and health of the employees they supervise is a primary responsibility of supervisors. To accomplish this obligation, supervisors will:

- ◆ Conduct pre-job safety orientations with all workers to outline safety and health rules, regulations and policies. Review rules as the job or conditions change or as required.
- ◆ Require the proper care and use of all required protective equipment.
- ◆ Identify and eliminate job hazards through job safety analysis procedures.
- ◆ Inform and train all employees on the hazardous chemicals they MAY encounter under normal working conditions or during an emergency situation.
- ◆ Conduct crew/leader meetings the first five minutes of each work shift to discuss safety matters and work plans for the work day.
- ◆ Receive and take initial action on employee suggestions, awards or disciplinary measures.
- ◆ Train all employees in the safe and efficient methods of accomplishing each job or task.
- ◆ Review accident trends and establish prevention measures.

Bushman & Associates Health and Safety Manual

- ◆ Attend safety meetings and actively participate in the proceedings.
- ◆ Participate in investigations and inspections on safety and health related matters.
- ◆ Promote employee participation in the safety and health program.
- ◆ Actively follow the progress of injured workers and display an interest in their rapid recovery and return to work. The Department of Labor & Industries can assist you in developing a program to effectively follow and manage injury claims.

EMPLOYEES:

Observe the items of responsibility established in this document as well as job safety rules, which may apply to specific task assignments.

EMPLOYEE SAFETY AND HEALTH RESPONSIBILITIES

- ◆ Report all on the job injuries promptly.
- ◆ Report all equipment damage to your supervisor immediately.
- ◆ Don't take chances – use your safety equipment as directed.
- ◆ Follow instructions – ask questions of your supervisor if required.
- ◆ Observe and comply with all safety signs and regulations.
- ◆ Report all unsafe conditions or situations that are potentially hazardous.
- ◆ Operate only equipment you are qualified to operate. When in doubt, ask for directions.
- ◆ Talk to management about problems that affect your safety or work conditions.

The most important part of this program is the individual employee – You! Without your cooperation, the most stringent program can be ineffective. Protect yourself and your fellow worker by following the rules. Remember: Work safely so you can go home to your family and friends.

Don't take chances – THINK SAFETY FIRST!

PERSONAL WORK RULES

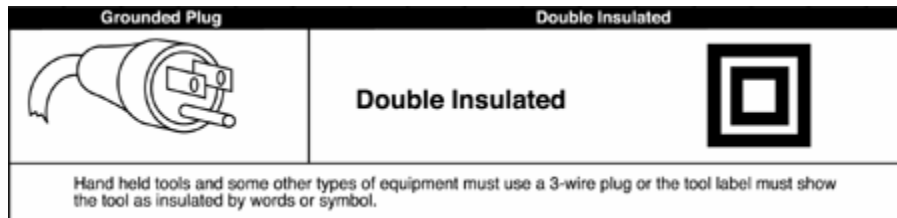
- ◆ Report every injury, no matter how slight, to your supervisor immediately.
- ◆ Horseplay, fighting, gambling, possession of firearms and possession or use of alcoholic beverages or drugs, except as prescribed by a qualified physician, are strictly forbidden.
- ◆ Running on any construction site is strictly prohibited except in extreme emergencies.
- ◆ Wear clothing suitable for the weather and your work. Torn, loose clothing, cuffs, sleeves, etc., are hazardous and could cause accidents.
- ◆ Jewelry (rings, bracelets, neck chains, etc.) shall not be worn.
- ◆ Hard hats must be worn in all required areas. ANSI Class III Safety Vests will be worn by all workers near Traffic
- ◆ Proper eye protection must be worn where you are exposed to flying objects, dust, harmful rays, chemicals, flying particles, etc.
- ◆ Proper footwear must be worn on all construction sites; safety boots are highly recommended. The wearing of sport shoes, sandals, dress shoes and similar footwear is strictly prohibited.
- ◆ Always use gloves, aprons or other protective clothing when handling rough materials, chemicals, and hot or cold objects.
- ◆ When spray painting, finish spraying, burning, exposed to large quantities of dust, or to other toxic hazards, always wear the correct respirators as required.
- ◆ Special safety equipment is for your protection. Use it when required. Keep it in good condition and report loss or damage of it immediately.
 1. Hard hats will be provided for visitors to used when entering areas designated as "Hard Hat Area." They will be kept in the construction site office and to be returned when leaving.
 2. Safety Glasses will be provided for visitors. They will be kept in the construction site office and to be returned when leaving.
 3. Ear Protection
 4. Subcontractors on site will be required to have their own equipment and use it as required for safety.

GENERAL SAFETY RULES

- ◆ Always store materials in a safe manner. Tie down or support piles if necessary to prevent falling, rolling or shifting.
- ◆ Fall protection gear shall be used whenever working at 6 feet or higher above the ground/ floor in a space that is not properly protected by guardrails and kick plates. If in question, review situation with Supervisor before proceeding with work.
- ◆ Shavings, dust, scraps, oil or grease should not be allowed to accumulate. Good housekeeping is a part of the job.
- ◆ Refuse piles must be removed as soon as possible. Refuse is a safety and fire hazard.
- ◆ Remove or clinch nails in lumber that has been used or removed from a structure.
- ◆ Immediately remove all loose materials from stairs, walkways, ramps, platforms, etc.
- ◆ Do not block aisles, traffic lanes, fire exits, gangways or stairs.
- ◆ Avoid shortcuts – use ramps, stairs, walkways, ladders, etc.
- ◆ Standard guardrails must be erected around all floor openings and excavations must be barricaded. Contact your supervisor for the correct specifications.
- ◆ Get help with heavy or bulky materials to avoid injury to you or damage to material.
- ◆ Keep all tools and materials away from the edges of scaffolding, platforms, shaft openings, etc.
- ◆ Do not use tools with split, broken or loose handles, burred or mushroomed heads. Keep cutting tools sharp and carry all tools in a container.
- ◆ Know the correct use of hand and power tools. Use the right tool for the job.
- ◆ All electrical power tools (unless double insulated), extension cords and equipment shall be properly grounded.
- ◆ All electrical power tools and extension cords shall be properly insulated. Damaged cords shall be replaced.

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- ◆ Know the location/use of fire extinguishing equipment and the procedure for sounding an alarm.
- ◆ Flammable liquids shall be used only in small amounts at the work site, in approved safety cans.
- ◆ Proper guards or shields must be installed on all power tools before use. Do not use any tools without the guards in their proper working condition. No “homemade” handles or extensions (cheaters) will be used!
- ◆ Do not operate any power tool or equipment unless you are trained in its operation and authorized by your firm to do so.
- ◆ Use tools only for their designed purpose.
- ◆ Do not remove, deface or destroy any warning, danger sign or barricade, or interfere with any form of accident prevention device or practice provided for your use or that is being used by other workmen.
- ◆ All electrical power equipment and tools must be grounded or double insulated.
- ◆ Use tools only for their designed purpose.



WALK-AROUND SAFETY INSPECTIONS

Walk-around safety inspections will be conducted at the beginning of each job and at least weekly thereafter.

- The inspections will be conducted jointly by one member of management and one employee, elected by the employees, as their authorized representative.
- The inspections will be documented and the documentation will be made available for inspection by representatives of the Department of Labor and Industries.
- The records of the walk-around inspections will be maintained until the completion of the job.

SAFETY DISCIPLINARY POLICY

Bushman & Associates believes that a safety and health accident prevention program is unenforceable without some type of disciplinary policies. In order to maintain a safe and healthy workplace, employees must be aware of all company, State, and Federal safety and health regulations as they apply to specific job duties. The following disciplinary policy will be applied to all safety or health violations.

The following steps will be followed unless the seriousness of the violation would dictate going directly to Step 2 or Step 3.

1. A first time violation will be discussed orally between a manager and the employee under his/her supervision. This will be done as soon as possible. The purpose will be to educate the employee.
2. A second time offense will be followed up in written form and a copy of this written documentation entered into the employee's personnel folder.
3. A third time violation will result in time off or possible termination, depending upon the seriousness of the violation. This is per the personnel policy manual.

SAFETY DISCIPLINARY POLICY FOR SUBCONTRACTORS AND THEIR EMPLOYEES

The following steps will be followed unless the seriousness of the violation would dictate going directly to Step 2 or Step 3.

1. A first time violation will be discussed orally between site construction manager and subcontractor/subcontractor employee to educate him/her on the safety issue. A note in the Daily Report is to be made. Subcontractor's site manager to be informed for their safety meeting.
2. A second time offense by same subcontractor – a verbal reprimand followed up in writing to the Subcontractor and noted in the Daily Report. This action is dependent upon the severity of the offence.
3. A third time violation for a major offence – the worker will be requested to leave the job site and a call to the Subcontractor requiring this person to be replaced or not to return until permission is granted by Bushman & Associates .

LADDER SAFETY RULES

GENERAL

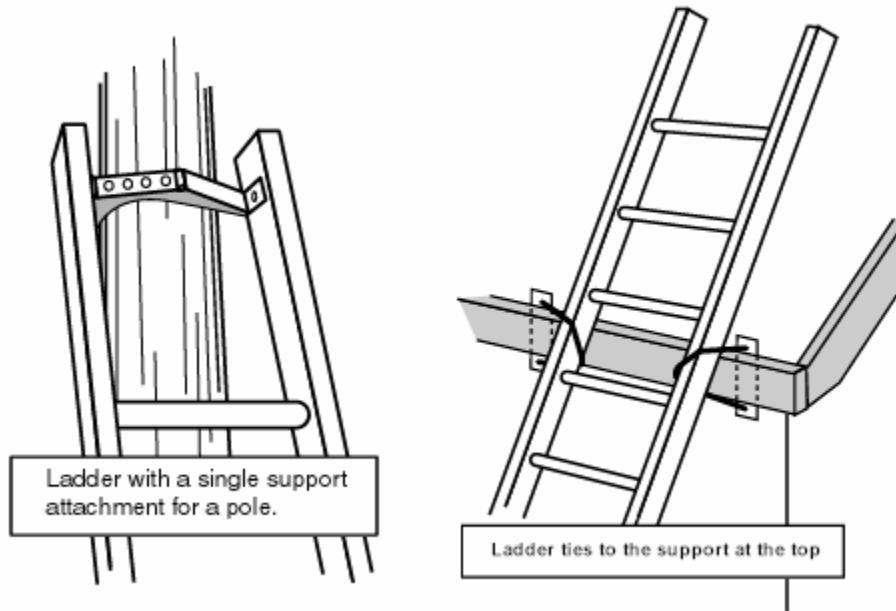
- ♦ Inspect for physical defects before use.
- ♦ Ladders are not to be painted except for numbering purposes.
- ♦ Do not use ladders for skids, braces, workbenches or any purpose other than climbing.
- ♦ When you are ascending or descending a ladder, do not carry objects that will prevent you from grasping the ladder with both hands.
- ♦ Always face the ladder when ascending or descending.
- ♦ If you must place a ladder over a doorway, barricade the door to prevent its use and post a warning sign.
- ♦ Only one person is allowed on a ladder at a time.
- ♦ Always keep both feet on the ladder rungs. Do not step laterally from a ladder onto another object.
- ♦ Do not jump from a ladder when descending.
- ♦ All joints between steps, rungs and side rails shall be tight.
- ♦ Safety feet shall be in good working order and in place.
- ♦ Rungs shall be free of grease and/or oil.
- ♦ Fall protection gear shall be used whenever working at 6 feet or higher above the ground/floor in a space that is not properly protected by guardrails and kick plates. If in question, review situation with Supervisor before proceeding with work.

STRAIGHT TYPE OR EXTENSION LADDERS

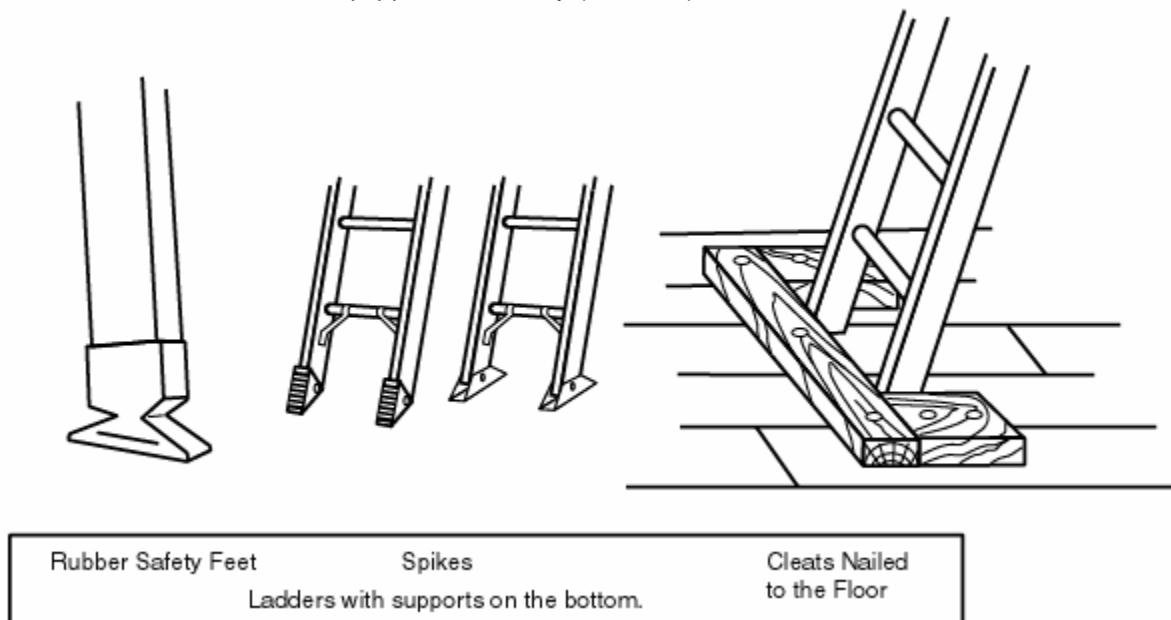
- ♦ All straight or extension ladders must be at least three feet beyond the supporting object when used as an access to an elevated work area.
- ♦ After raising the extension portion of a two or more stage ladders to the desired height, check to be sure that the safety dogs or latches are engaged.
- ♦ All extension or straight ladders must be secured or tied off at the top.
- ♦ All ladders must be equipped with safety (non-skid) feet.
- ♦ Portable ladders shall be used at such a pitch that the horizontal distance from the top support to the foot of the ladder is about one-quarter of the working length of the ladder.

STEPLADDERS

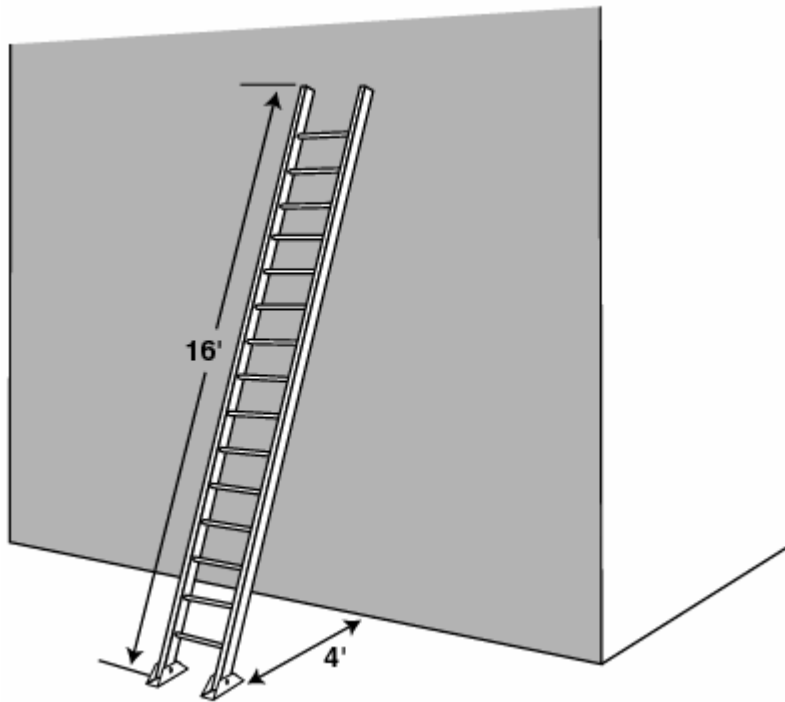
- ♦ Do not place tools or materials on the steps or platform of a stepladder.
- ♦ Do not use the top two steps or ladder cap of a stepladder as a step or stand.
- ♦ Always level all four feet and lock spreaders in place.
- ♦ Do not use a stepladder as a straight ladder.



- All ladders must be equipped with safety (non-skid) feet.



- Portable ladders must be used at such a pitch that the horizontal distance from the top support to the foot of the ladder is about one-quarter of the working length of the ladder.



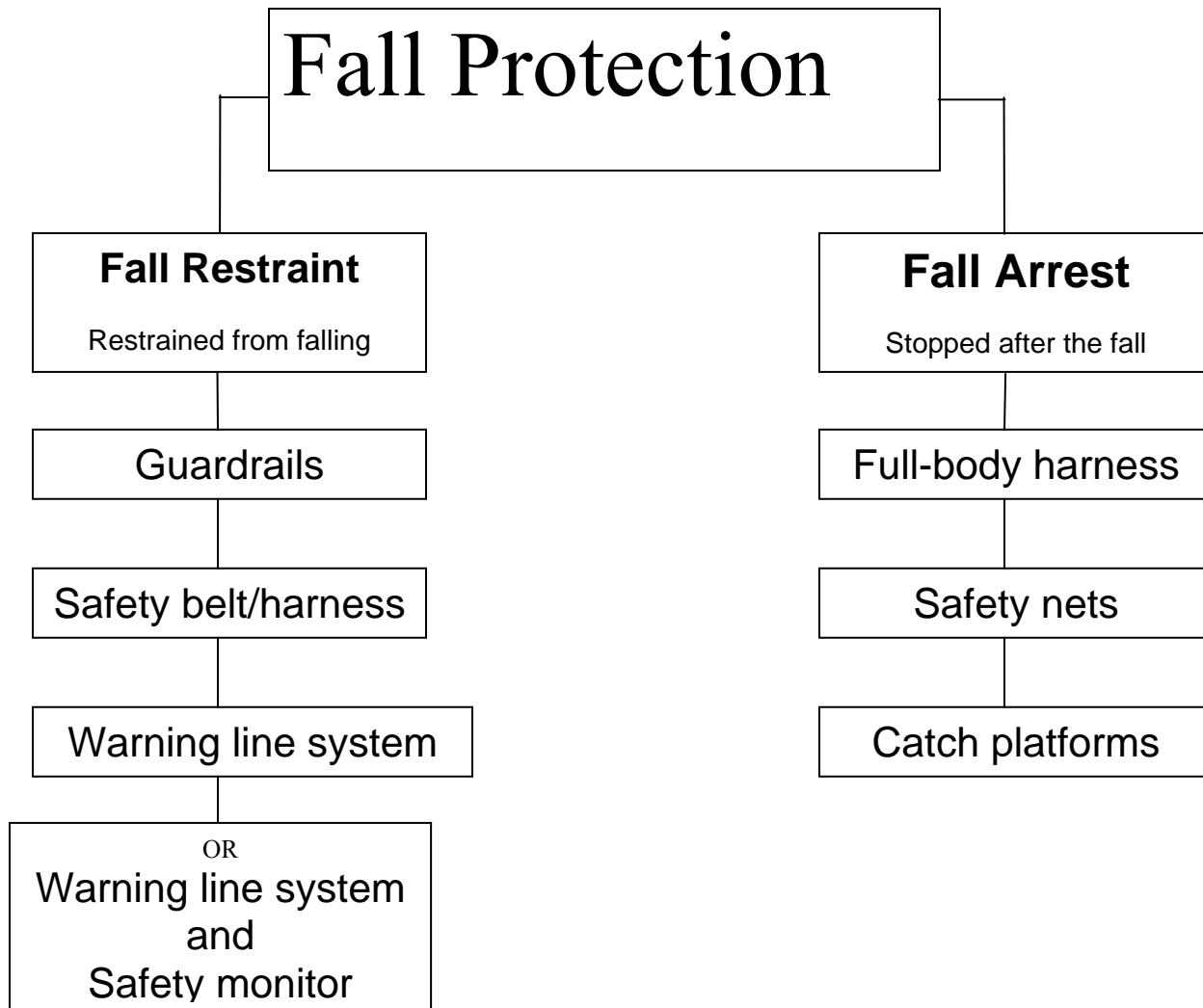
Fall Protection Safety Rules

Falls from elevation are a major cause of injuries and deaths in the construction industry. We at Bushman & Associates are committed to eliminating injuries caused by fall hazards by instituting a program of 100% fall protection for all fall hazards 10 feet or greater.

All work sites with fall hazards of 6 feet or more will have a site-specific fall protection work plan completed before any employees begin work. The employees on that specific job will be trained in the fall hazards and the method used to implement fall protection. The attached training guide will be used to train employees in the inspection and maintenance of their fall protection equipment, as well as fall protection selection criteria. All employees will use fall protection when there is exposure to a fall hazard of 6 feet or more. Employees who fail to follow this policy are subject to disciplinary action, up to and including dismissal.

The evaluation of the jobsite and the completion of the fall protection work plan will be done by a designated "competent person," who has an understanding of OSHA fall protection requirements, the fall protection systems available for use, and has the authority to take corrective action to eliminate employee exposure to fall hazards.

Fall protection will be provided either through the use of a fall arrest system or a fall restraint system as shown below and thoroughly described in the fall protection work plan available on site for review.



FALL PROTECTION TRAINING GUIDE FOR EMPLOYEES

Safety Belt, Harness and Lanyard Inspection and Maintenance

I. ANSI Classification:

- Class I Body belts – used to restrain a person from falling.
- Class II Chest harness – used for restraint purposes (NOT for vertical free fall hazards).
- Class III Full body harness – used for fall arrest purposes. Can also be used for fall restraint.
- Class IV Suspension/position belt – used to suspend or support the worker. If a fall arrest hazard exists this must be supplemented by use of a safety harness.

II. Inspection Guidelines:

To maintain their service life and high performance, all belts and harnesses must be inspected prior to each use for mildew, wear, damage and other deteriorations. Visual inspection before each use is just common sense. Periodic tests by a trained inspector for wear, damage or corrosion should be part of the safety program. Inspect your equipment daily and replace it if any of the defective conditions in this manual are found.

Belt inspection:

1. Beginning at one end, holding the body side of the belt toward you, grasp the belt with your hands six to eight inches apart. Bend the belt in an inverted “U”. The resulting surface tension makes damaged fibers or cuts easier to see.
2. Follow this procedure the entire length of the belt or harness. Watch for frayed edges, broken fibers, pulled stitches, cuts, or chemical damage.
3. Special attention should be given to the attachment of buckles and Dee Rings to webbing. Note any unusual wear, frayed or cut fibers, or distortion of the buckles or Dees.
4. Inspect for frayed or broken strands. Broken webbing strands generally appear as tufts on the webbing surface. Any broken, cut, or burned stitches will be readily seen.
5. Rivets should be tight and immovable with fingers. Body side rivet base and outside rivet burr should be flat against the material. Bent rivets will fail under stress.

Especially note condition of Dee Ring rivets and Dee Ring metal wear pads (if any). Discolored, pitted or cracked rivets indicate chemical corrosion.

6. The tongue, or billet, of the belt receives heavy wear from repeated buckling and unbuckling. Inspect for loose, distorted, or broken grommets. Belts using punched holes without grommets should be checked for torn or elongated holes, causing slippage of the buckle tongue.

7. Tongue Buckle:

Buckle tongues should be free of distortion in shape and motion. They should overlap the buckle frame and move freely back and forth in their socket. Roller should turn freely on frame. Check for distortion or sharp edges.

8. Friction Buckle:

Inspect the buckle for distortion. The outer bars and center bars must be straight. Pay special attention to corners and attachment to points of the center bar.

9. Sliding Bar Buckle:

Inspect buckle frame and sliding bar for cracks, distortions, or sharp edges.

Sliding bar should move freely. Knurled edge will slip if worn smooth. Pay special attention to

Bushman & Associates Health and Safety Manual

corners and ends of sliding bar.

FALL PROTECTION TRAINING GUIDE FOR EMPLOYEES Safety Belt, Harness and Lanyard Inspection and Maintenance (continued)

Lanyard inspection:

When inspecting lanyards, begin at one end and work to the opposite end. Slowly rotate the lanyard so that the entire circumference is checked. Spliced ends require particular attention. Hardware should be examined under procedures also detailed below, i.e., Snaps, Dee Ring, and Thimbles.

1. Steel

While rotating the steel lanyard, watch for cuts, frayed areas, or unusual wearing patterns on the wire. Broken strands will separate from the body of the lanyards.

2. Webbing

While bending webbing over a pipe or mandrel, observe each side of the webbed lanyard. This will reveal any cuts or breaks. Swelling, discolorations, cracks, and charring are obvious signs of chemical or heat damage. Observe closely for any breaks in stitching.

3. Rope

Rotation of the rope lanyard while inspecting from end to end will bring to light any fuzzy, worn, broken, or cut fibers. Weakened areas from extreme loads will appear as a noticeable change in original diameter. The rope diameter should be uniform throughout, following a short break-in-period.

FALL PROTECTION TRAINING GUIDE FOR EMPLOYEES (continued)

Guidelines for worker protection where fall arrest or fall restraint systems are used.

1. Selection and use considerations:

The kind of personal fall arrest system selected should match the particular work situation, and any possible free fall distance should be kept to a minimum. Consideration should be given to the particular work environment. For example, the presence of acids, dirt, moisture, oil, grease, etc., and their effect on the system, should be evaluated. Hot or cold environments may also have an adverse affect on the system. Wire rope should not be used where an electrical hazard is anticipated. As required by the standard, the employer must plan to have means available to promptly rescue an employee should a fall occur, since the suspended employee may not be able to reach a work level independently.

Where lanyards, connectors, and lifelines are subject to damage by work operations such as welding, chemical cleaning, and sandblasting, the component should be protected, or other securing systems should be used. The employer should fully evaluate the work conditions and environment (including seasonal weather changes) before selecting the appropriate personal fall protection system. Once in use, the system's effectiveness should be monitored. In some cases, a program for cleaning and maintenance of the system may be necessary.

2. Testing considerations:

Before purchasing or putting into use a personal fall arrest system, an employer should obtain from the supplier information about the system based on its performance during testing so that the employer can know if the system meets this standard. Testing should be done using recognized test methods. Not all systems may need to be individually tested; the performance of some systems may be based on data and calculations derived from testing of similar systems, provided that enough information is available to demonstrate similarity of function and design.

FALL PROTECTION TRAINING GUIDE FOR EMPLOYEES

Fall Protection System Considerations (continued)

3. Component compatibility considerations:

Ideally, a personal fall arrest system is designed, tested, and supplied as a complete system. However, it is common practice for lanyards, connectors, lifelines, deceleration devices, and body harnesses to be interchanged since some components wear out before others. The employer and employee should realize that not all components are interchangeable. For instance, a lanyard should not be connected between a body harness and a deceleration device of the self-retracting type since this can result in additional free fall for which the system was not designed. Any substitution or change to a personal fall arrest system should be fully evaluated or tested by a competent person to determine that it meets the standard, before the modified system is put in use.

4. Employee training considerations:

Thorough employee training in the selection and use of personal fall arrest systems is imperative. As stated in the standard, before the equipment is used, employees must be trained in the safe use of the system. This should include the following: Application limits; proper anchoring and tie-off techniques; estimation of free fall distance, including determination of deceleration distance, and total fall distance to prevent striking a lower level; methods of use; and inspection and storage of the system. Careless or improper use of the equipment can result in serious injury or death. Employers and employees should become familiar with this material, as well as manufacturer's recommendations, before a system is used. Of uppermost importance is the reduction in strength caused by certain tie-offs (such as using knots, tying around sharp edges, etc.) and maximum permitted free fall distance. Also, to be stressed are the importance of inspections prior to use, the limitations of the equipment, and unique conditions at the worksite which may be important in determining the type of system to use.

5. Instruction considerations:

Employers should obtain comprehensive instructions from the supplier as to the system's proper use and application, including, where applicable:

- a. The force measured during the sample force test;
- b. The maximum elongation measured for lanyards during the force test;
- c. The deceleration distance measured for deceleration devices during the force test;
- d. Caution statements on critical use limitations;
- e. Application limits;
- f. Proper hook-up, anchoring and tie-off techniques, including the proper dee-ring or other attachment point to use on the body harness for fall arrest;
- g. Proper climbing techniques;
- h. Methods of inspection, use, cleaning, and storage; and
- i. Specific lifelines that may be used. This information should be provided to employees during training.

6. Inspection considerations:

Personal fall arrest systems must be regularly inspected. Any component with any significant defect, such as cuts, tears, abrasions, mold, or undue stretching; alterations or additions which might affect its efficiency; damage due to deterioration; contact with fire, acids, or other corrosives; distorted hooks or faulty hook springs; tongues unfitted to the shoulder of buckles; loose or damaged mountings; nonfunctioning parts; or wearing or internal deterioration in the ropes must be withdrawn from service immediately, and should be tagged or marked as unusable, or destroyed.

7. Rescue considerations:

When personal fall arrest systems are used, the employer must assure that employees can be promptly rescued or can rescue themselves should a fall occur. The availability of rescue personnel, ladders or other rescue equipment should be evaluated. In some situations, equipment that allows employees to

rescue themselves after the fall has been arrested may be desirable, such as devices that have descent capability.

FALL PROTECTION TRAINING GUIDE FOR EMPLOYEES

Fall Protection System Considerations (continued)

8. Tie-off considerations:

- a. One of the most important aspects of personal fall protection systems is fully planning the system before it is put into use. Probably the most overlooked component is planning for suitable anchorage points. Such planning should ideally be done before the structure or building is constructed so that anchorage points can be incorporated during construction for use later for window cleaning or other building maintenance. If properly planned, these anchorage points may be used during construction, as well as afterwards.
- b. Employers and employees should at all times be aware that the strength of a personal fall arrest system is based on its being attached to an anchoring system which does not significantly reduce the strength of the system (such as a properly dimensioned eye-bolt/snap-hook anchorage). Therefore, if a means of attachment is used that will reduce the strength of the system, that component should be replaced by a stronger one, but one that will also maintain the appropriate maximum arrest force characteristics.
- c. Tie-off using a knot in a rope lanyard or lifeline (at any location) can reduce the lifeline or lanyard strength by 50 percent or more. Therefore, a stronger lanyard or lifeline should be used to compensate for the weakening effect of the knot, or the lanyard length should be reduced (or the tie-off location raised) to minimize free fall distance, or the lanyard or lifeline should be replaced by one which has an appropriately incorporated connector to eliminate the need for a knot.
- d. Tie-off of a rope lanyard or lifeline around an "H" or "I" beam or similar support can reduce its strength as much as 70 percent due to the cutting action of the beam edges. Therefore, a webbing lanyard or wire core lifeline should be used around the beam; or the lanyard or lifeline should be protected from the edge; or free fall distance should be greatly minimized.
- e. Tie-off where the line passes over or around rough or sharp surfaces reduces strength drastically. Such a tie-off should be avoided or an alternative tie-off rigging should be used. Such alternatives may include use of a snap-hook/dee-ring connection, wire rope tie-off, an effective padding of the surfaces, or an abrasion-resistance strap around or over the problem surface.
- f. Horizontal lifelines may, depending on their geometry and angle of sag, be subjected to greater loads than the impact load imposed by an attached component. When the angle of horizontal lifeline sag is less than 30 degrees, the impact force imparted to the lifeline by an attached lanyard is greatly amplified. For example, with a sag angle of 15 degrees, the force amplification is about 2:1 and at 5 degrees sag, it is about 6:1. Depending on the angle of sag, and the line's elasticity, the strength of the horizontal lifeline and the anchorages to which it is attached should be increased a number of times over that of the lanyard. Extreme care should be taken in considering a horizontal lifeline for multiple tie-offs. The reason for this is that in multiple tie-offs to a horizontal lifeline, if one employee falls, the movement of the falling employee and the horizontal lifeline during arrest of the fall may cause other employees to also fall. Horizontal lifeline and anchorage strength should be increased for each additional employee to be tied-off. For these and other reasons, the design of systems using horizontal lifelines must only be done by qualified persons. Testing of installed lifelines and anchors prior to use is recommended.
- g. The strength of an eye-bolt is rated along the axis of the bolt and its strength is greatly reduced if the force is applied at an angle to this axis (in the direction of shear). Also, care should be exercised in selecting the proper diameter of the eye to avoid accidental disengagement of snap-hooks not designed to be compatible for the connection.

FALL PROTECTION TRAINING GUIDE FOR EMPLOYEES

Fall Protection System Considerations (continued)

- h. Due to the significant reduction in the strength of the lifeline/lanyard (in some cases, as much as a 70 percent reduction), the sliding hitch knot should not be used for lifeline/lanyard connections except in emergency situations where no other available system is practical. The "one-and-one" sliding hitch knot should never be used because it is unreliable in stopping a fall. The "two-and-two," or "three-and-three" knot (preferable), may be used in emergency situations; however, care should be taken to limit free fall distance to a minimum because of reduced lifeline/lanyard strength.

9. Vertical lifeline considerations.

As required by the standard, each employee must have a separate lifeline when the lifeline is vertical. The reason for this is that in multiple tie-offs to a single lifeline, if one employee falls, the movement of the lifeline during the arrest of the fall may pull other employees' lanyards, causing them to fall as well.

10. Snap-hook considerations:

- a. Required by this standard for all connections, locking snap-hooks incorporate a positive locking mechanism in addition to the spring loaded keeper, which will not allow the keeper to open under moderate pressure without someone first releasing the mechanism. Such a feature, properly designed, effectively prevents roll-out from occurring.
- b. The following connections must be avoided (unless properly designed locking snap-hooks are used) because they are conditions which can result in roll-out when a nonlocking snap-hook is used:
 - Direct connection of a snap-hook to a horizontal lifeline.
 - Two (or more) snap-hooks connected to one dee-ring.
 - Two snap-hooks connected to each other.
 - A snap-hook connected back on its integral lanyard.
 - A snap-hook connected to a webbing loop or webbing lanyard.
 - Improper dimensions of the dee-ring, rebar, or other connection point in relation to the snap-hook dimensions which would allow the snap-hook keeper to be depressed by a turning
 - motion of the snap-hook.

11. Free fall considerations:

The employer and employee should at all times be aware that a system's maximum arresting force is evaluated under normal use conditions established by the manufacturer, and in no case using a free fall distance in excess of 6 feet (1.8 m). A few extra feet of free fall can significantly increase the arresting force on the employee, possibly to the point of causing injury. Because of this, the free fall distance should be kept at a minimum, and, as required by the standard, in no case greater than 6 feet (1.8 m). To help assure this, the tie-off attachment point to the lifeline or anchor should be located at or above the connection point of the fall arrest equipment to harness. (Since otherwise additional free fall distance is added to the length of the connecting means (i.e. lanyard).) Attaching to the working surface will often result in a free fall greater than 6 feet (1.8 m). For instance, if a 6-foot (1.8 m) lanyard is used, the total free fall distance will be the distance from the working level to the body harness attachment point plus the 6 feet (1.8 m) of lanyard length. Another important consideration is that the arresting force that the fall system must withstand also goes up with greater distances of free fall, possibly exceeding the strength of the system.

FALL PROTECTION TRAINING GUIDE FOR EMPLOYEES

Fall Protection System Considerations cont'd

12. Elongation and deceleration distance considerations. Other factors involved in a proper tie-off are elongation and deceleration distance. During the arresting of a fall, a lanyard will experience a length of stretching or elongation, whereas activation of a deceleration device will result in a certain stopping distance. These distances should be available with the lanyard or device's instructions and must be added to the free fall distance to arrive at the total fall distance before an employee is fully stopped. The additional stopping distance may be very significant if the lanyard or deceleration device is attached near or at the end of a long lifeline, which may itself add considerable distance due to its own elongation. As required by the standard, sufficient distance to allow for all of these factors must also be maintained between the employee and obstructions below, to prevent an injury due to impact before the system fully arrests the fall. In addition, a minimum of 12 feet (3.7 m) of lifeline should be allowed below the securing point of a rope grab type deceleration device, and the end terminated to prevent the device from sliding off the lifeline. Alternatively, the lifeline should extend to the ground or the next working level below. These measures are suggested to prevent the worker from inadvertently moving past the end of the lifeline and having the rope grab become disengaged from the lifeline.
13. Obstruction considerations:

The location of the tie-off should also consider the hazard of obstructions in the potential fall path of the employee. Tie-offs that minimize the possibilities of exaggerated swinging should be considered.
14. Other considerations:

Because of the design of some personal fall arrest systems, additional considerations may be required for proper tie-off. For example, heavy deceleration devices of the self-retracting type should be secured overhead in order to avoid the weight of the device having to be supported by the employee. Also, if self-retracting equipment is connected to a horizontal lifeline, the sag in the lifeline should be minimized to prevent the device from sliding down the lifeline to a position that creates a swing hazard during fall arrest. In all cases, manufacturer's instructions should be followed.

SCAFFOLD SAFETY RULES

General (only qualified and authorized persons may assemble/disassemble scaffolds).

- ☐ Before starting work on a scaffold, inspect it for the following:
 - ☐ Are guardrails, toe boards and planking in place and secure?
 - ☐ Are locking pins at each joint in place?
 - ☐ Are all wheels on moveable scaffolds locked?
- ☐ Do not attempt to gain access to a scaffold by climbing on it (unless it is specifically designed for climbing), always use a ladder.
- ☐ Scaffolds and their components shall be capable of supporting four times the maximum intended load.
- ☐ Any scaffold including accessories such as braces, brackets, trusses, screw legs, ladders, etc., damaged or weakened in any way shall be immediately repaired or replaced.
- ☐ Scaffold planks shall extend over their end supports not less than six inches or more than 12 inches, unless otherwise specifically required.
- ☐ Scaffold platforms shall not be less than 18 inches wide unless otherwise specifically required or exempted.
- ☐ Where persons are required to work or pass under the scaffold, scaffolds shall be provided with a screen between the toe board and guardrail, extending along the entire opening, of No. 18 gauge U.S. Standard wire 1/2 inch mesh or equivalent protection.
- ☐ All scaffolds must be erected level and plumb, and on a solid footing.
- ☐ Do not change or remove scaffold members unless authorized.
- ☐ Do not allow workmen to ride on a rolling scaffold when it is being moved. Remove or secure all materials and tools on deck before moving.
- ☐ Do not alter any scaffold member by welding, burning, cutting, drilling or bending.

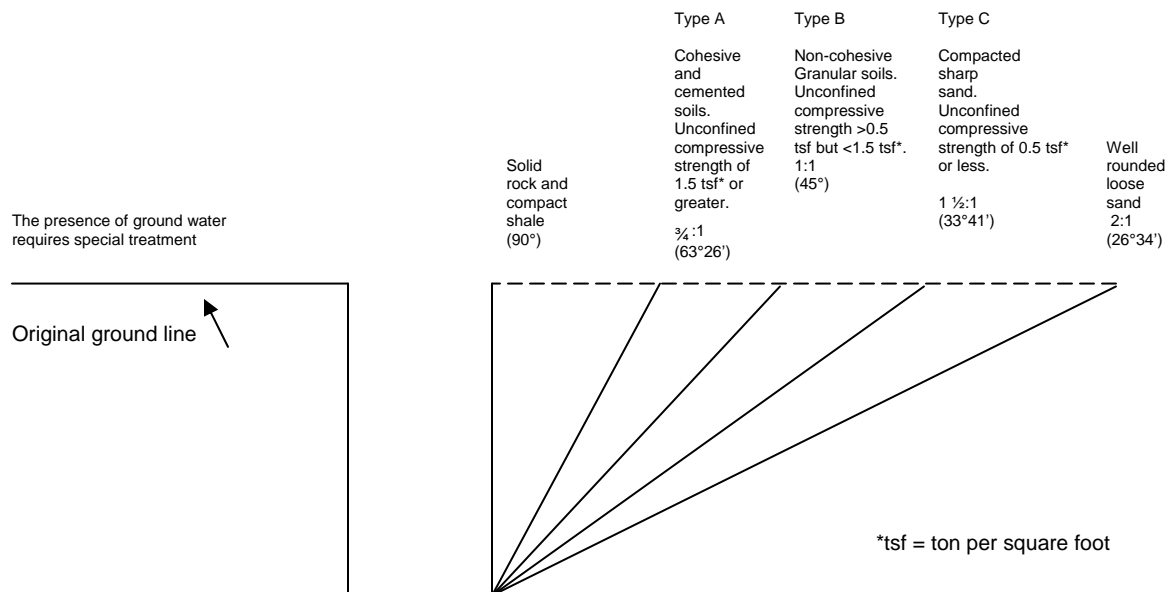
MOTORIZED VEHICLES AND EQUIPMENT SAFETY RULES

- ☐ Do not ride on motorized vehicles or equipment unless a proper seat is provided for each rider.
- ☐ Always be seated when riding authorized vehicles (unless they are designed for standing.)
- ☐ Always use your seat belts in the correct manner.
- ☐ Obey all speed limits and other traffic regulations.
- ↑ Always be aware of pedestrians and give them the right-of-way.
- ↑ Always inspect your vehicle or equipment before and after daily use.
- ↑ Never mount or dismount vehicles or equipment while they are still in motion.
- ↑ Do not dismount any vehicle without first shutting down the engine, setting the parking brake, and securing the load.
- ↑ Do not allow other persons to ride the hook or block, dump box, forks, bucket, or shovel of any equipment.
- ↑ Each operator must be knowledgeable of all hand signals and obey them. Any equipment used on site needing communication with another for operation – all parties operating the equipment to review the hand signals to be used and meanings of each prior to using the equipment
- ↑ Each operator is responsible for the stability and security of their load.

TRENCHING AND EXCAVATING SAFETY RULES

1. The determination of the angle of repose and design of the supporting system shall be based on careful evaluation of pertinent factors such as:
2. Depth and/or cut/soils.
3. Possible variation in water content of the material while excavation is open.
4. Anticipated changes in materials from exposure to air, sun, water or freezing.
5. Loading imposed by structures, equipment, overlaying material or stored material.
6. Vibration from equipment, blasting, traffic or other sources.

For sloping of sides of excavations



7. Walkways or bridges with standard railings shall be provided when employees or equipment are required to cross over excavations.
8. The walls and faces of all excavations in which employees are exposed to danger from moving ground shall be guarded by a shoring system, sloping of the ground or some other equivalent means.
9. **No person shall be permitted under loads** handled by power shovels, derricks or hoists.
10. **All employees shall be protected with personal protective equipment** for the protection of the head, eyes, respiratory system, hands, feet and other parts of the body.

HAZARD COMMUNICATION PROGRAM

PURPOSE:

The purpose of the Hazard Communication Program is to evaluate the hazards of all chemicals produced or imported by chemical manufacturers or importers. Information concerning their hazards shall be transmitted to affected employers and employees before they use the products.

The code specifically requires employers to train employees in the protective practices implemented in their workplace, the labeling system used, how to obtain and use MSDSs, the physical and health hazards of the chemicals, and the recognition, avoidance and prevention of accidental entrance of hazardous chemicals into the work environment.

PROCEDURE:

- ☐ Inventory Lists - Know the hazardous chemicals in your workplace that are a potential physical or health hazard. Make an inventory list of these hazardous chemicals; this list is part of Bushman & Associates ~SE's written program.
- ☐ MSDS - Make sure there is a material safety data sheet (MSDS) for each chemical and that the inventory list and labeling system reference the corresponding MSDS for each chemical.
- ☐ Labeling System - Each container entering the workplace must be properly labeled with the identity of the product, the hazardous warning, and the name and address of the manufacturer.
- ☐ Information and Training - Determine appropriate ways in which to inform and train employees on the specific chemicals in your workplace and their hazards.
- ☐ Written Program - Develop, implement and maintain a comprehensive written hazard communication program that includes provisions for container labeling, material safety data sheets, and an employee training program.

CONTAINER LABELING

Containers received for use will be clearly labeled as to the contents, include the appropriate hazard warning, and list the name and address of the manufacturer.

The supervisor in each section will label all secondary containers with either an extra copy of the original manufacturer's label or with labels that have the identity and the appropriate hazard warning. For help with labeling, see the office manager or area supervisor.

NOTE: If written alternatives to in-plant container labeling are used, add a description of the system used.

MATERIAL SAFETY DATA SHEETS (MSDS)

The Office Manager or Human Resources Manager is responsible for establishing and monitoring Bushman & Associates ~SE's MSDS program. He/she will make sure procedures are developed to obtain the necessary information and will review incoming MSDSs for new or significant health and safety information. He/she will see that any new information is passed on to affected employees. If an MSDS is not available, please let him/her know.

NOTE: If an alternative to printed material safety data sheets is used (such as computer data) provide a description of the format.

The Office Manager or Human Resources Manager is responsible for Bushman & Associates ~SE's employee training program. He/she will see that all program elements specified below are carried out.

Prior to starting work, each new employee will attend a health and safety orientation that includes the following information and training:

- ☐ An overview of the requirements contained in the Hazard Communications Program.
- ☐ Hazardous chemicals present at his/her workplace.
- ☐ Physical and health risk of the hazardous chemical.
- ☐ The symptoms of overexposure. Procedures to follow if employees are overexposed to hazardous chemicals.
- ☐ How to determine the presence or release of hazardous chemicals in his/her work area.
- ☐ How to reduce or prevent exposure to hazardous chemicals through use of control procedures, work practices and personal protective equipment.
- ☐ Steps the company has taken to reduce or prevent exposure to hazardous chemicals.
- ☐ Location of the MSDS file and written hazard communication program

Prior to introducing a new chemical hazard into any section of this company, each employee in that section will be given information and training as outlined above for the new chemical hazard.

MATERIAL SAFETY DATA SHEETS (MSDS)

HAZARDOUS NON-ROUTINE TASKS

Periodically, employees are required to perform hazardous non-routine tasks. Some examples of non-routine tasks are: confined space entry, operation of compressed air equipment, working next to the edge of the roof. Prior to starting work on such projects, each affected employee will be given information by the manager about the hazardous chemicals he or she may encounter during such activity. This information will include specific chemical hazards, and protective and safety measures the employee can use. Also included will be steps Bushman & Associates ~SE is using to reduce hazards, including ventilation, respirators, presence of another employee and emergency procedures.

MULTI-EMPLOYER WORKPLACES

It is the responsibility of the manager to provide other employers, with employees at the work site, copies of MSDSs (or make them available at a central location) for any hazardous chemicals that the employee may be exposed to. The manager will also inform other employers of any precautionary measures that need to be taken to protect employees during normal operating conditions or in foreseeable emergencies, and provide an explanation of the labeling system that is used at the work site.

LIST OF HAZARDOUS CHEMICALS

The following is a list of all known hazardous chemicals used by our employees. Further information on each chemical may be obtained by reviewing MSDSs located in Addendum 1 (Tab 11 of Appendix). If no list is provided, then no hazardous chemicals are known to be used by our employees with respect to the work on this project.

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MATERIAL SAFETY DATA SHEETS (MSDS) (continued)

EMPLOYEE ORIENTATION CHECKLIST - HAZARDOUS SUBSTANCES

Employee Name: _____ **Title:** _____ **Date:** _____

This checklist is to inform employees of Bushman & Associates's Hazard Communication Program. Place a check in each box to indicate that the subject has been covered.

- o The purpose of the Hazard Communication Program is to require chemical manufacturers or importers to assess the hazards of chemicals they produce or import. All employers must provide information to their employees about the hazardous chemicals to which they may be exposed.

Employees must be informed about the Hazard Communication Program; labels, and other forms of warning; material safety data sheets; and they must have training on the hazardous substances they may encounter.

- o The supervisor has reviewed the hazardous chemical list with the employee.
- o The supervisor has shown the employee the:
 - o Location of hazardous chemicals within the employee's worksite.
 - o Location of the written Hazard Communication Program.
 - o Location of the material safety data sheets for all hazardous chemicals in the employee's assigned work area.
 - o Location of the list of persons trained and authorized to handle the hazardous chemicals.

The signatures below document that the appropriate elements have been discussed to the satisfaction of both the supervisor and employee and that both accept responsibility for maintaining a safe and healthful work environment.

Date signed

Employee Signature

Date signed

Supervisor Signature

Bushman & Associates Health and Safety Manual

NOTE TO SUPERVISOR: If this employee is expected to actually handle chemicals, please provide for training before employee begins actual work.

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FIRST AID TRAINING, KITS, AND POSTER

PURPOSE:

To afford employees immediate and effective attention should an injury result, Bushman & Associates ~SE will attempt to have at least one first aid certified employee available. To meet these objectives, the following procedures will be followed:

- ☐ All supervisors or persons in charge of crews will be trained in first aid unless their duties require them to be away from the job site, whereby other persons will be designated as the recognized first aid trained employee.
- ☐ Other persons will be trained as designated by management in order to augment or surpass the standard requirements.
- ☐ Valid first aid cards are recognized as those that include both first aid and cardiopulmonary resuscitation (CPR) and have not reached the expiration date.

First aid kits will be in accordance with OSHA requirements and will be located at convenient locations.

Posters listing emergency numbers, procedures, etc., will be strategically located, such as on the first aid kits, at telephones, etc.

SAFETY BULLETIN BOARD

PURPOSE:

The Safety Bulletin Board is an important vehicle to increase employee awareness of safety and health policy and communicate management's safety message.

PROCEDURE:

- ☐ The Safety Bulletin Board is located in the job site office and will be maintained by the Safety Committee Representative in each office.
- ☐ Posters, Safety Committee minutes, and other information that becomes dated or worn should be changed periodically.
- ☐ The following items are required to be posted:
 - ☐ Industrial Insurance Poster LI-210-191
 - ☐ Notice (to report all injuries) LI-416-80
 - ☐ Citation and Notice (as appropriate)
 - ☐ OSHA-200 Summary (specifically during the month of February)

FIRST AID PROCEDURES IN CONSTRUCTION

First aid at the job site is done on a Good Samaritan basis. If employees are involved in a situation involving blood, they should:

- ☐ Avoid skin contact with blood/OPIM (other potentially infectious materials) by letting the victim help as much as possible, and using gloves provided in first aid kit.
- ☐ Remove clothing, etc., with blood on it after rendering help.
- ☐ Wash thoroughly with soap and water to remove blood. A 10% chlorine bleach solution is good for disinfecting the area contaminated with blood (spills, etc.).
- ☐ Report such first aid incidents within the shift to supervisors (time, date, blood presence, exposure, those helping).

The employee should receive full Hepatitis B vaccinations as soon as possible, but no later than 24 hours, after the first aid incident. If an exposure incident occurs, the following steps should be followed: a post exposure evaluation, follow-up treatment, follow-up as listed in CDC guidelines.

Training covering the above information should be conducted at job site safety meetings.

PROCEDURE FOR INJURY OR ILLNESS ON THE JOB

Owner or supervisor shall immediately take charge.

- ☐ Call 911 EMS.
- ☐ Render Good Samaritan first aid, if possible by a first aid certified employee.
- ☐ Arrange for transportation (ambulance, helicopter, company vehicle, etc.), depending on seriousness.
- ☐ Notify top management if not already present. Superintendent and/or Project Administrative Assistant
- ☐ Do not move anything unless necessary, pending investigation of accident.
- ☐ Accompany or take injured person to doctor, hospital, home, etc. (depending on extent of injuries).
- ☐ Take injured person to family doctor if available.

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FIRST AID PROCEDURES IN CONSTRUCTION (continued)

- ☐ Remain with injured until relieved.
- ☐ When the injured person's immediate family is known by the management or supervisor, they should properly notify these people, preferably in person, or have an appropriate person do so.

DOCUMENTATION PROCEDURES:

- ☐ Minor Injuries *(requiring doctor/outpatient care):*
After the employee receives medical attention following an accident, the immediate supervisor along with any witness to the accident will conduct an investigation. The findings of the investigation shall be documented on accident investigation forms. Copies of the completed investigation reports shall be given to the Managing Principal and the Safety Committee Chairperson.

- ☐ Major Injuries *(fatality or multiple hospitalization):*

In addition to the procedures listed for Minor Injuries, the Managing Principal, Supervisor, and Safety Committee Chairperson are to be notified immediately and begin an investigation.

In the case of a fatality or if two or more employees are hospitalized, the accident shall be reported to the nearest office of the Department of Labor & Industries, or call the toll-free telephone number, 1-800-423-7233, within 24 hours after the occurrence of the accident. The report shall relate the circumstances, the number of fatalities and the extent of any injuries.

Note: Any equipment involved in an accident resulting in an immediate fatality is not to be moved until a representative of the Department of Labor & Industries has inspected it. If, however, it is necessary to move the equipment to prevent further accidents or to remove the victim, the equipment may be moved as required.

- ◆ Near-Misses *(likelihood of personal injury or property damage):*
To the greatest extent possible, all "near-miss" accidents shall be investigated by the Managing Principal (if situation warrants), supervisor, and Safety Committee Chairperson. Documentation will be made on the firm's accident investigation forms. A near-miss accident is defined as any unplanned event where damage did not result, but the likelihood of personal injury to the employee was great. If the conditions, which permitted the near miss to exist, are not eliminated, they will continue to be potential causes of an accident, which could eventually result in personal injury.

OCCUPATIONAL INJURY AND ILLNESS RECORDKEEPING

PURPOSE:

In accordance with applicable requirements of OSHA's standards, Bushman & Associates ~SE's records will be kept by Engineered Lining Systems, Inc. They will keep the appropriate records as follows:

- ☐ Maintain a log and Summary of Occupational Injuries and Illness on OSHA 300 forms. Recordable cases include:
 - ◆ Every occupational death.
 - ◆ Every occupational illness.
 - ◆ Every occupational injury that involves: unconsciousness; inability to perform all phases of the regular job; inability to work full-time on a regular job; temporary assignments to another job; medical treatment other than first aid.
- ☐ Keep copies of all reports generated when an employee is injured on the job.
- ☐ During the month of February, post on the Safety Bulletin Board the completed summary portion of the OSHA 300 form for the previous year.
- ☐ Maintain records for five years following the year the injury occurred.
- ☐ Enter each recordable injury or illness on the log as early as feasible, but no later than six working days after receiving the information that a recordable case has occurred.
- ☐ In addition to the OSHA 300, a supplementary record for each occupational injury or illness (OSHA 101) will be maintained. Other reports, such as worker's compensation forms, are acceptable alternatives for the OSHA 101 if they contain the information required by the OSHA 101.

ACCIDENT INVESTIGATION AND REPORTING

The purpose of an investigation is to find the cause of an accident and prevent future occurrences, NOT to fix blame. An unbiased approach is necessary to obtain objective findings. A manager/supervisor shall complete an Accident Report (Supervisor) and the employee shall complete an Accident Report (Employee).

- ☐ Write down all details of the accident immediately, no matter how small or apparently insignificant they may seem. Remember that the longer the time lapse between the accident and the report, the hazier the witnesses' memories become and the less accurate the report.
- ☐ Write down the names and statements of the witnesses. Interview witnesses one at a time (try to keep witnesses from talking to each other before you interview them). Talk with anyone who has knowledge of the accident, even if they did not actually witness the mishap. Consider taking signed statements in cases where facts are unclear or there is an element of controversy.
- ☐ If possible, interview the injured worker at the scene of the accident and "walk" him/her through a reenactment. Be careful not to actually repeat the act that caused the injury.
- ☐ Graphically document details of the accident; area, tools, and equipment. Use sketches, diagrams and photos as needed, and take measurements when appropriate. Note the object, tool, machine, building detail, or chemical substance associated with the accident.
- ☐ Note the condition of the object associated with the accident - was it in a safe or unsafe condition at the time of the accident?
- ☐ Identify the type of accident. Give details such as whether the individual fell into the machinery, was struck by the object, etc.
- ☐ Indicate any unsafe acts on the part of the person involved which may have precipitated the accident or been a contributing element.
- ☐ Incorporate in the report any recommendation for future safety, the date of the recommendation, and the date of its initial institution. How will you prevent such accidents in the future? Every investigation should include an action plan.
- ☐ Focus on causes and hazards. Develop an analysis of what happened, how it happened and how it could have been prevented. Determine what caused the accident itself, not just the injury.
- ☐ If a third party or defective product contributed to the accident, save any evidence. It could be critical to the recovery of the claim costs.

HOW TO HOLD A GOOD SAFETY MEETING

- ☐ Be certain everyone knows the time and location of the next meeting.
- ☐ Insist that everyone attend. Before the next meeting, remind those that were late or failed to attend that *attendance is not an option*.
- ☐ Pick an appropriate topic.
- ☐ Start the meeting on time.
- ☐ Don't waste time - give the meeting your undivided attention.
- ☐ Discuss the topic you have chosen and prepared. Don't wait until the meeting to choose your topic.
- ☐ Use handouts or posters to illustrate your topic.
- ☐ Discuss current job safety events, accidents and close calls.
- ☐ Encourage employees to discuss safety problems as they arise. Do not save safety concerns for the meetings. Allow some time for employee questions or input at the end of the meeting.
- ☐ Invite managers or owners to speak. Ask fellow employees to speak on a safety topic.
- ☐ If you prevented one accident, it is time well spent. Your topic may be one that some employees have heard many times, but there may be one person who is new or has never been told of the safety requirement for the topic. Repeating topics several times during the course of a project is beneficial as long as it applies to the work being done.
- ☐ Follow up on employee concerns or questions and get back to them with the answer before the next meeting.
- ☐ Be certain to document the attendance and the topics discussed.

CREW LEADER MEETINGS

We believe that there is no magic formula for the prevention of accidents - hard work and perseverance are required, with the crew leader being the key to a successful result.

- ☐ Purpose: To assist in the detection and elimination of unsafe conditions and work procedures.
- ☐ Weekly meetings: These meetings should be held in accordance with the various circumstances involved or when necessity dictates. No set pattern will suit all cases. It is important, however, that the leader talk daily on accident prevention and immediately on witnessing an unsafe act.
 - ☐ Safety meetings shall be held at least once a week.
 - ☐ The attendance and subjects discussed shall be documented and maintained on file for one year.
 - ☐ Copies of the minutes should be made available to the employees by posting or other means.

SCOPE OF ACTIVITIES:

- ☐ Certain employees as may be designated by their supervisors will assist.
- ☐ Conduct in-house safety inspections with supervisor concerned.
- ☐ Accident investigation to uncover trends.
- ☐ Review accident reports to determine means or elimination.
- ☐ Accept and evaluate employee suggestions.
- ☐ Review job procedures and recommend improvements.
- ☐ Monitor the safety program's effectiveness.
- ☐ Promote and publicize safety.

Documentation: The following form is available to assist in documentation activities of crew/leader meetings: Crew Leader Safety Meeting, Form F411-049-000.

APPENDICES

The following Forms, Checklists and Guides are intended as aids. They are samples that may be used on the project as the manager sees fit. One exception is the OSHA Record keeping forms. These are required of all firms with more than ten employees.

- ☐ OSHA Form 300 – Log of Work Related Injuries & Illness
- ☐ Supervisor's Accident Investigation Forms
- ☐ Employee Accident Investigation Forms
- ☐ Crew Leader Meeting Documentation Forms
- ☐ Health & Safety Inspection Checklist
- ☐ Safety Inspection Guide
- ☐ Barometer of Safety Attitudes - Construction Self-Inspection Guide
- ☐ Equipment Safety Inspection Checklist and Sample Form
- ☐ Job Safety Analysis Worksheet
- ☐ Fall Protection Work Plan, Sample (Site Specific)
- ☐ MSDS Sheets – Attached if needed for project
- ☐ Emergency Procedures – Job / Site Specific

Evacuation Procedure

Emergency Contact List – Employees

Emergency Hospital Route from Fort Drum to House of Good Samaritan
Medical Center & Hospital, Watertown, NY

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- ☐ OSHA FORM 300 HERE

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BUSHMAN & ASSOCIATES ACCIDENT REPORT (SUPERVISOR)

Supervisor's name: _____ Title: _____

Exact date/time accident reported to you: _____ / _____

Injured employee's name/title: _____ / _____

Who reported it? _____

Names of witnesses: _____

Describe the accident (attach additional page(s) if necessary): _____

Was first aid required? _____ Did the accident require a doctor's treatment? _____

Date/time of next doctor appointment: _____ / _____

Was this employee competent and skillful in his/her job? _____

What were the causes? _____

Will this be a time loss case? _____

If so, was the employee instructed to keep the company informed of his/her progress? _____

If not, why? _____

Has this employee had other injuries? _____ If yes, how many? _____

EXPLAIN IN DETAIL: What part of the body was injured? _____

Other details of the accident: _____

Supervisor's signature: _____ Date: _____

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BUSHMAN & ASSOCIATES ACCIDENT REPORT (EMPLOYEE)

Employee's name: _____ Title: _____

Exact time of injury: _____ Date of injury: _____

Location where injury occurred: _____

Name of person to whom this incident was reported: _____ Time: _____

Names of witnesses: _____

Summarize what you think happened: _____

What could have been done to avoid this accident? _____

EXPLAIN IN DETAIL: What part of your body was injured? BE SPECIFIC _____

Is this an original injury or a re-injury? _____

If a re-injury, who was the employer? _____ Claim number _____

Would you be willing to perform light-duty work during your recovery? _____

Date/time you sought medical attention _____ / _____

Whom did you see? _____ Office/hospital: _____

Employee signature: _____ Date: _____

This form is to be returned to your employer as soon as possible.

Signature / date of person receiving report _____ / _____

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BUSHMAN & ASSOCIATES CREW LEADER SAFETY MEETING MINUTES

Project:	
Project No.:	
Minutes of Meeting No.:	
Date:	
Location:	

Present Y/N	Attendees (Name)	Company	Phone Number

Item	Description	Status	Opened	Due	Action By

The preceding is presumed to be a complete and correct record of the significant items and actions agreed upon at the above meeting. Work is proceeding on the basis of this record. Please advise the writer immediately of any additions or corrections to these minutes.

Prepared by: Bushman & Associates ~SE, Inc.

Signed: _____

Dated: _____

Attachments:

[illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible]

[illegible]

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SAFETY INSPECTION GUIDE

A - Adequate at the time of the inspection

B - Needs immediate attention

A B

JOB SITE INFORMATION

- ☐ ☐ OSHA and other job site warning posters posted
- ☐ ☐ Scheduled safety meetings held and documented
- ☐ ☐ Adequate employee training - general and specific
- ☐ ☐ Medical services, first aid equipment, stretchers, and a qualified first aid certified employee
- ☐ ☐ Emergency telephone numbers, such as police department, fire department, doctor, hospital and ambulance, posted

HOUSEKEEPING AND SANITATION

- ☐ ☐ Working areas generally neat
- ☐ ☐ Waste and trash regularly disposed
- ☐ ☐ Enclosed chute provided when material dropped outside of building from over 20 feet
- ☐ ☐ Lighting adequate for all work tasks
- ☐ ☐ Projecting nails removed or bent over
- ☐ ☐ Oil and grease removed from walkways and stairs
- ☐ ☐ Waste containers provided and used
- ☐ ☐ Passageways and walkways clear
- ☐ ☐ Sanitary facilities adequate and clean
- ☐ ☐ Potable water available for drinking
- ☐ ☐ Disposable drinking cups and containers for used cups provided

FIRE PREVENTION

- ☐ ☐ Fire protection program developed
- ☐ ☐ Fire instructions provided to employees
- ☐ ☐ Adequate fire extinguishers, identified, checked and accessible
- ☐ ☐ Phone number of fire department posted
- ☐ ☐ Hydrants clear, access open
- ☐ ☐ Good housekeeping in evidence
- ☐ ☐ NO SMOKING signs posted and enforced (where needed)
- ☐ ☐ Temporary heating devices safe; adequate ventilation provided
- ☐ ☐ Proper fire extinguishers provided

ELECTRICAL INSTALLATIONS

- ☐ ☐ Adequate wiring, well insulated, grounded, protected from damage
- ☐ ☐ Assured Grounding program followed
- ☐ ☐ (or) Ground fault circuit interceptors used
- ☐ ☐ Terminal boxes equipped with required covers

HAND TOOLS

- ☐ ☐ Proper tools being used for each job
- ☐ ☐ Safe carrying practices used
- ☐ ☐ Company and employees' tools regularly inspected and maintained

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SAFETY INSPECTION GUIDE (continued)

POWER TOOLS

- o o Good housekeeping where tools are used
- o o Tools and cords in good condition
- o o Proper grounding of all tools
- o o Proper instruction in use provided
- o o All mechanical safeguards in use
- o o Tools neatly stored when not in use
- o o Right tool being used for the job at hand
- o o Wiring properly installed

POWER-ACTIVATED TOOLS

- o o All operators licensed
- o o Tools and charges protected from unauthorized use
- o o Competent instruction and supervision provided
- o o Tools used only on recommended materials
- o o Safety goggles or face shields worn
- o o Flying hazards checked by backing up, removal of personnel, or use of captive stud tool

LADDERS

- o o Ladders inspected and in good condition
- o o Ladders properly secured to prevent slipping, sliding or falling
- o o Side rails extended 36" above the top of the landing
- o o Job-built ladders properly constructed
- o o Stepladders fully open when in use
- o o Metal ladders not used around electrical hazards
- o o Ladders not painted
- o o Ladders properly stored
- o o Ladder safety feet in use

SCAFFOLDING

- o o Erection properly supervised
- o o All structural members meet safety factors
- o o All connectors secure
- o o Scaffold tied to the structure when required
- o o Working areas free of debris, snow, ice and grease
- o o Foot sills and mud sills provided
- o o Workers protected from falling objects
- o o Scaffold plumb and square, with cross-bracing
- o o Guard rails, intermediate rails and toeboards in place
- o o Adequate, sound planking provided
- o o Scaffold equipment in good working order
- o o Ropes and cables in good condition

HEAVY EQUIPMENT

- o o Inspection and maintenance records up to date
- o o Lights, brakes, warning signals operative
- o o Wheels chocked when necessary
- o o Haul roads well maintained and properly laid out
- o o Equipment is properly secured when not in use
- o o Shut off devices on hose air lines, in case of hose failure
- o o Noise arresters in use

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- o o ROPS in place

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SAFETY INSPECTION GUIDE (continued)

MOTOR VEHICLES

- ☐ ☐ Floor and wall openings planked over or barricaded
- ☐ ☐ Roadways or walkway hazards effectively barricaded
- ☐ ☐ Barricades illuminated or reflectorized at night
- ☐ ☐ Traffic control devices used when appropriate
- ☐ ☐ Inspection and maintenance records up to date
- ☐ ☐ Operators qualified for vehicle in use
- ☐ ☐ Local and state vehicle laws and regulations observed
- ☐ ☐ Brakes, lights, warning devices operative
- ☐ ☐ Weight limits and load sizes controlled
- ☐ ☐ Personnel transported in a safe manner
- ☐ ☐ All glass in good condition
- ☐ ☐ Back-up signals provided
- ☐ ☐ Fire extinguishers installed where required
- ☐ ☐ SLOW MOVING VEHICLE signs used when required

REPAIR SHOPS AND GARAGES

- ☐ ☐ Fire hazards eliminated
- ☐ ☐ Fuels and lubricants dispensed in a safe location
- ☐ ☐ Good housekeeping maintained
- ☐ ☐ Lighting adequate for work tasks
- ☐ ☐ Carbon monoxide vented to outside and adequate ventilation provided inside
- ☐ ☐ All fuels and lubricants in proper containers

HOISTS, CRANES AND DERRICKS

- ☐ ☐ Cables and sheaves regularly inspected
- ☐ ☐ Slings and chains, hooks and eyes inspected before each use
- ☐ ☐ Equipment firmly supported
- ☐ ☐ Outriggers used if needed
- ☐ ☐ Power lines inactivated, removed, or at a safe distance
- ☐ ☐ Proper loading for capacity at lifting radius. Rated load capacities posted?
- ☐ ☐ All equipment properly lubricated and maintained
- ☐ ☐ Signalmen where needed
- ☐ ☐ Signals posted, understood and observed
- ☐ ☐ Inspection and maintenance logs maintained
- ☐ ☐ Hazard signs posted and visible to operator

BARRICADES

- ☐ ☐ Floor and wall openings planked over or barricaded
- ☐ ☐ Roadways or walkway hazards effectively barricaded
- ☐ ☐ Barricades illuminated or reflectorized at night
- ☐ ☐ Traffic control devices used when appropriate

HANDLING AND STORAGE OF MATERIALS

- ☐ ☐ Materials properly stored or stacked
- ☐ ☐ Passageways clear
- ☐ ☐ Stacks on firm footing, not too high
- ☐ ☐ Materials protected against weather conditions
- ☐ ☐ Trash chutes safeguarded and properly used
- ☐ ☐ Dust protection observed
- ☐ ☐ Traffic controlled in the storage area

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SAFETY INSPECTION GUIDE (continued)

EXPLOSIVES

- ☐ ☐ Qualified operators and supervision during all explosives operations
- ☐ ☐ Proper transport vehicles as required by DOT and OSHA
- ☐ ☐ State and local laws and regulations observed
- ☐ ☐ Storage magazines constructed per regulations
- ☐ ☐ Cases opened ONLY with wooden tools
- ☐ ☐ NO SMOKING signs posted and observed where appropriate
- ☐ ☐ Detonators tested before each shot
- ☐ ☐ All personnel familiar with signals; signals properly used at all times
- ☐ ☐ Inspection after each shot
- ☐ ☐ Proper protection and accounting for all explosives at all times
- ☐ ☐ Proper disposition of wrappings, waste and scrap
- ☐ ☐ Nearby residents advised of blasting cap danger
- ☐ ☐ Radio frequency hazards checked

FLAMMABLE GASES AND LIQUIDS

- ☐ ☐ All containers approved and clearly identified
- ☐ ☐ Proper storage practices observed
- ☐ ☐ Fire hazards checked
- ☐ ☐ Proper types and number of extinguishers nearby
- ☐ ☐ Proper method for moving cylinders used

WELDING AND CUTTING

- ☐ ☐ Operators qualified
- ☐ ☐ Screens and shields used when needed
- ☐ ☐ Goggles, welding helmets, gloves, clothing used as required
- ☐ ☐ Equipment in safe operating condition
- ☐ ☐ Electrical equipment grounded
- ☐ ☐ Power cables and hoses protected and in good repair
- ☐ ☐ Fire extinguishers of proper type nearby
- ☐ ☐ Surrounding area inspected for fire hazards
- ☐ ☐ Flammable materials protected or removed
- ☐ ☐ Gas cylinders secured upright
- ☐ ☐ Cylinder caps in use

EXCAVATION AND SHORING

- ☐ ☐ Adjacent structures properly shored
- ☐ ☐ Excavation shored or cutback (angle of repose) as required
- ☐ ☐ Roads and sidewalks supported and protected
- ☐ ☐ Material stored away from excavations
- ☐ ☐ Excavation barricades and fighting adequate
- ☐ ☐ Equipment a safe distance from edge of excavation
- ☐ ☐ Ladders provided
- ☐ ☐ Equipment ramps adequate
- ☐ ☐ Observer provided during trenching operations

DEMOLITION

- ☐ ☐ Written Demolition Plan
- ☐ ☐ Protection of adjacent structures
- ☐ ☐ Material chutes used; floor openings for material disposal barricaded

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- o o Sidewalk and other public protection provided
- o o Clear opening space for trucks and other vehicles
- o o Adequate access ladders or stairs maintained

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SAFETY INSPECTION GUIDE (continued)

PILE DRIVING

- o o Stored piles properly secured
- o o Unloading only by properly instructed workers
- o o Steam lines, slings, etc., in safe operating condition
- o o Piledriving rigs properly supported
- o o Cofferdams maintained and inspected
- o o Adequate pumping available

STEEL ERECTION

- o o Fall protection provided with safety nets, planked floors or personnel resistant devices
- o o Hard hats worn as required
- o o Tools and materials secured from falling
- o o Fire hazards at rivet, forge and welding operations eliminated
- o o Floor openings covered or barricaded
- o o Ladders, stairs, or other safe access provided
- o o Daily inspection of hoisting apparatus
- o o Employees prohibited from riding the ball or loads

HIGHWAY RIGHT OF WAY CONSTRUCTION

- o o Laws and ordinances observed
- o o Competent flaggers properly instructed, dressed, area posted
- o o Adequate traffic control devices used through construction area
- o o Equipment cleared from right-of-way
- o o Adequate marking and maintenance of detours approaching construction area
- o o Dust controlled
- o o Adequate lighting for night crews

CONCRETE CONSTRUCTION

- o o Forms properly installed and braced
- o o Adequate shoring, plumbed and cross-braced
- o o Shoring remains in place until strength is attained
- o o Proper curing period and procedures followed
- o o Heating devices checked for fire safety
- o o Mixing and transport equipment supported; traffic planned and routed
- o o Adequate runways and ramps provided for concrete placement equipment
- o o Employees protected from cement dust
- o o Hard hats, boots, gloves, eye protection, and skin protection worn at all times
- o o Nails bent over or removed and stripped material removed from area

MASONRY

- o o Scaffolding procedures meet at least minimum requirements
- o o Masonry saws equipped and grounded, dust protection provided
- o o Hoisting equipment in safe operating condition and used by qualified personnel
- o o Limited access zone established
- o o Walls over 8 feet in height adequately braced

BACK SAFETY

- o o Team lifting used for heavy or awkward loads
- o o Mechanical lifting devices used when appropriate
- o o Back care training provided to all employees
- o o Bent-knee lifting used by workers
- o o Back support belts worn when appropriate
- o o Work hardening program used for returning time-loss employees
- o o Employees do "warm-up" exercises before strenuous work

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SAFETY INSPECTION GUIDE (continued)

PERSONAL PROTECTIVE EQUIPMENT MONITORED BY SUPERVISOR

- ☐ ☐ Eye protection
- ☐ ☐ Face shields
- ☐ ☐ Written respirator program; respirators fit tested; replaced cartridges; cleaning and maintenance
- ☐ ☐ Helmets and hoods
- ☐ ☐ Foot protection
- ☐ ☐ Rubber or plastic gloves, aprons, and sleeves for chemical protection
- ☐ ☐ Electrician's rubber gloves and protectors

HAZARD COMMUNICATION PROGRAM

- ☐ ☐ Chemical inventory list developed and maintained
- ☐ ☐ Containers properly labeled
- ☐ ☐ Material Safety and Data Sheets collected and available
- ☐ ☐ Adequate employee information and training provided
- ☐ ☐ Written program available
- ☐ ☐ Employee training certificates signed

CONFINED SPACE

- ☐ ☐ Written Confined Space Program
- ☐ ☐ Competent instruction and supervision provided
- ☐ ☐ Hot work permits obtained if needed prior to entry and work
- ☐ ☐ Evaluation and monitoring; sampling devices adequate, calibrated, used
- ☐ ☐ Adequate ventilation; testing and monitoring during operation
- ☐ ☐ Respirators, standby person, harness/lifeline at the site
- ☐ ☐ Employee training certificates signed

Note: Categories or items on this checklist may be added to or eliminated if they do not pertain to your operation.

BAROMETER OF SAFETY ATTITUDES CONSTRUCTION SELF INSPECTION GUIDE

- o Power lines: Minimum 10' clearance / insulate – de-energize, under 50 kw; over 50 kw.
- o Trench/excavation: Any trench four feet or more must be sloped, shored or braced.
- o Guardrails: Any opening four feet or more above ground level must be guarded.
- o Standard guardrail: Top rail = 36" - 42" above working surface, Mid rail = 18" - 22" with toe board
- o Scaffold/guardrail: Fully planked
- o Flights of stairs: Four or more risers must have handrails
- o Fall protection: Any exposure to the hazard of falling from elevations 6' or greater must be eliminated by the use of safety harness/belt, lanyard or lifeline, horizontal lines, or centenary lines. Positive fall protection must be used at all times.
- o Open belts and pulleys, chains and sprockets and points of operation must be guarded to prevent accidental contact. Air compressors and electric motor pulleys are most common hazards.
- o Radial saws: Cutting head must return easily to start position when released; blade must not extend past the edge of the work table; off/on switch should be at front of operator's position.
- o Table saws: Upper hood guard; anti-kickback, push stick, belt, pulley
- o Circular saws: Blade guard instantly returns to covering position
- o Never wedge or pin a guard
- o Chainsaw: Ballistic nylon leg protection; eye, ear, face protection; hard hat
- o Angle grinders; 180' guard required
- o Ladders: Extend 36" above landing and secure to prevent displacement
- o Articulating boom lift: Safety at all times
- o Floor holes/openings covered, secured; be sure no tripping hazards in area
- o Extension cords/electric power tools, marked/covered by Assured Grounding Program
- o Minimum of short sleeve shirts, long pants and substantial footwear - no recreation shoes
- o Hard hat readily accessible/worn when overhead hazards exist
- o Oxygen/acetylene storage areas chained and separated
- o Personal protective equipment: head, eye, ear respiratory, and leg protection, high visibility vests
- o Housekeeping: Workers responsible for own areas of exposure
- o First aid kit - Fire extinguishers
- o Minimum of one person at all times - first aid and CPR trained
- o Accident prevention program
- o Crew leader meetings: Meetings specifically tailored to each subcontractor
- o Chemical hazard communication program

EQUIPMENT SAFETY INSPECTION CHECKLIST

- This form is used as a checklist for equipment coming into a project.
- The items to be checked are listed and are required to be checked as a minimum pre-work inspection.
- Any item that needs attention will be corrected before the equipment is put to work on the project.
- The report will be filed at the Field Office for the duration of the project. A copy will also be sent to the main office.
- These forms will be inspected by company safety personnel, as well as governmental safety representatives.
- The Project Manager is responsible for ensuring that the pre-operating safety check is properly done.

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EQUIPMENT SAFETY INSPECTION CHECKLIST

Date: _____

Equipment Number/Name: _____

Project: _____

All guards and fenders	_____	OK	_____	Needs Repair
Brakes	_____	OK	_____	Needs Repair
Lights – Front, Rear, Side				
Dash	_____	OK	_____	Needs Repair
Bakup Alarm – Horn	_____	OK	_____	Needs Repair
Ladders / Stairs /				
Hand Holds	_____	OK	_____	Needs Repair
ROPS	_____	OK	_____	Needs Repair
Seat Belts	_____	OK	_____	Needs Repair
Fire Extinguisher	_____	OK	_____	Needs Repair
Glass	_____	OK	_____	Needs Repair
Tires	_____	OK	_____	Needs Repair

Other Items Checked:

Oil – Level & Leaks	_____	OK	_____	Needs Repair	_____	Add	_____	Change
Antifreez – Level								
& Leaks	_____	OK	_____	Needs Repair	_____	Add	_____	Change

Fuel – Level & Leaks	_____	OK	_____	Needs Repair	_____	Add	_____	Change
Hydraulic Oil Level								
& Leaks	_____	OK	_____	Needs Repair	_____	Add	_____	Change
First Aid Kit	_____	OK	_____	Needs Repairs	_____	Add	_____	Change

Checked By: _____

Date

Repaired By: _____

Date

OPERATION_____Date_____

--	--	--

[illegible]

Bushman & Associates Health and Safety Manual

FALL PROTECTION WORK PLAN

SITE SPECIFIC

Job Name _____

Date Prepared _____

Person approving plan _____

Title Job Superintendent

Activities: Inspection and coordination of work performed or being performed.

Identify hazards in the work area: Uneven surfaces, debris, holes, overhead structural members, electrical, piping, and/or other installed systems.

Check methods of fall restraint or arrest to be used:

- | | | |
|--|---|---|
| <input type="checkbox"/> Standard guardrail | <input type="checkbox"/> Double lanyard system | <input type="checkbox"/> Safety net(s) |
| <input type="checkbox"/> top, middle & toe board | <input type="checkbox"/> Full body harness | <input type="checkbox"/> Float |
| <input type="checkbox"/> Horizontal lifeline | <input type="checkbox"/> Tie off point capable | <input type="checkbox"/> Restraint line |
| <input type="checkbox"/> Secured to existing strut | <input type="checkbox"/> of 5,000 lb. load | <input type="checkbox"/> Beam seat |
| <input type="checkbox"/> Shock absorber lanyard | <input type="checkbox"/> Retractable lanyard | <input type="checkbox"/> Scissor lift |
| <input type="checkbox"/> Drop line-rope grab | <input type="checkbox"/> Scaffold-with guardrail and toe boards | |
| <input type="checkbox"/> Boom lift | <input type="checkbox"/> Other (specify) Lanyard | |

Describe procedures for assembly, maintenance, inspection and disassembly system (attach separate sheet if more space is needed).

Describe procedures for handling and securing tools and equipment, and providing overhead protection for employees (attach separate sheet if more space is needed).

Bushman & Associates Health and Safety Manual

FALL PROTECTION WORK PLAN

SITE SPECIFIC (continued)

Describe method for prompt, safe removal of an injured employee(s).

Provide stick drawings of system configuration

I certify that I received fall protection orientation including the material covered in this plan.
Employee(s) signature and date:

_____	_____
_____	_____
_____	_____
_____	_____

This plan has been prepared as a general guideline.

Site Safety Officers

Depending on the Phase of the Job, one of the following persons on-site will be the Safety Officer for Bushman & Associates:

- Mr. James B. Bushman, President, Bushman & Associates, Inc.
- Dr. Bopinder Phull, Project Manager, Bushman & Associates, Inc.
- Mr. William P. Carlson, President, Cathodic Protection Management, Inc.

In the absence of the following three (3) individuals, the current senior manager for Bushman & Associates or their Prime Subcontractor for that phase of work will be the designated Safety Officer:

Bushman & Associates Health and Safety Manual

Fall Protection Work Plan Overview

Job Name: _____
Site Address: _____

Date: _____

Fall Hazards	Type of Fall Protection	Specific Location
Structural Steel Connection	_____	_____
Bolting	_____	_____
Decking	_____	_____
Welding	_____	_____
Acetylene Burning	_____	_____
Crane Supported Platforms	_____	_____
Boom Lift	_____	_____
Scissor Lift	_____	_____
Perimeter	_____	_____
Roof	_____	_____
Stairwells	_____	_____
Ladders	_____	_____
Scaffolds over 10 feet	_____	_____
Rolling Scaffolds	_____	_____
Exterior Scaffolds	_____	_____
Elevator Shafts	_____	_____
Wall Openings	_____	_____
Upper Floor material	_____	_____
Loading/unloading area	_____	_____

Check Fall Protection to be used

A - Standard guardrail
Top, middle & toe board
B - Horizontal lifeline
C - Secured to existing strut
D - Shock absorber lanyard
E - Drop line - rope grab
F - Boom lift

G - Double lanyard system
H - Full body harness
I - Tie off point capable
of 5,000 lb. Load
J - Retractable lanyard
K - Scaffold w/guardrail

L - Safety net(s)
M - Float
N - Restraint line
O - Beam seat
P - Scissor lift
Q - Other

Bushman & Associates Health and Safety Manual

Fall Protection Work Plan Overview

(continued)

Daily Inspection A visual inspection of all safety equipment shall be done daily or prior to each use. Defective equipment is to be tagged and removed from use immediately. The manufactures' recommendations for maintenance, inspection and for assemble and disassembly of equipment must be followed.

Overhead Protection Hardhats are required on all job sites and shall be worn. Warning signs, barricades and/or warning tape must be used to caution workers of existing hazards whenever present. Floor openings must be covered with wood or metal. In some cases debris nets or covered walkways may be used if the hazards warrant additional protection.

Tools and Materials Equipment is to be stored in tool shed or some other means of lock and key area each night and handed out daily, as needed. Power tools and cords shall be unplugged and locked up at night. Ladders may be secured to the existing structures when conditions impose a hazard. All materials are to be stored in a neat and orderly manner to avoid causing hazards blocking access and egress. All materials and equipment must be secured to restrict mobility from adverse weather conditions.

Removal of an injured worker First aid procedures should be performed as the situation requires. If the area is safe for entry first aid procedures should be started. Summon additional help, as needed, ambulance, fire or medical aid.

Dial 9-1-1

Telephone Location _____

Job Site Address _____

First Aid Kit Location _____

Training and Instruction Program All new employees are given instruction on the proper use and care of fall-protection devices before they begin work and must sign a training form stating that they have received this training.

This site-specific fall-protection program will be reviewed before work begins on the job site. The employee's attendance record will be signed and fall protection equipment use will be reviewed on a regular basis.

SIGNED OFF BY: _____
(Project Supervisor)

DATE: _____

Bushman & Associates Health and Safety Manual

House of Good Samaritan Medical Center & Hospital

(315) 785-4000

(800) 892-4785

(315) 785-4504

(315) 785-4399

**830 Washington St
Watertown, NY 13601**

Directions from Fort Drum Road to House of Good Samaritan Medical Center

Time	Mile	Instruction	For	Toward
9:00 AM	0.0	Depart SR-26, Fort Drum, NY 13602 on SR-26 (West)	1.5 mi	
9:03 AM	1.5	Bear LEFT (West) onto US-11	10.3 mi	
9:16 AM	11.9	Bear RIGHT (West) onto Ramp [SR-12]	54 yds	
9:16 AM	11.9	At roundabout, take the SECOND exit onto US-11 [Washington St]	0.8 mi	
9:17 AM	12.7	Arrive House of the Good Samaritan		

TRIP SUMMARY

Driving distance: 12.7 miles

Trip duration: 17 minutes

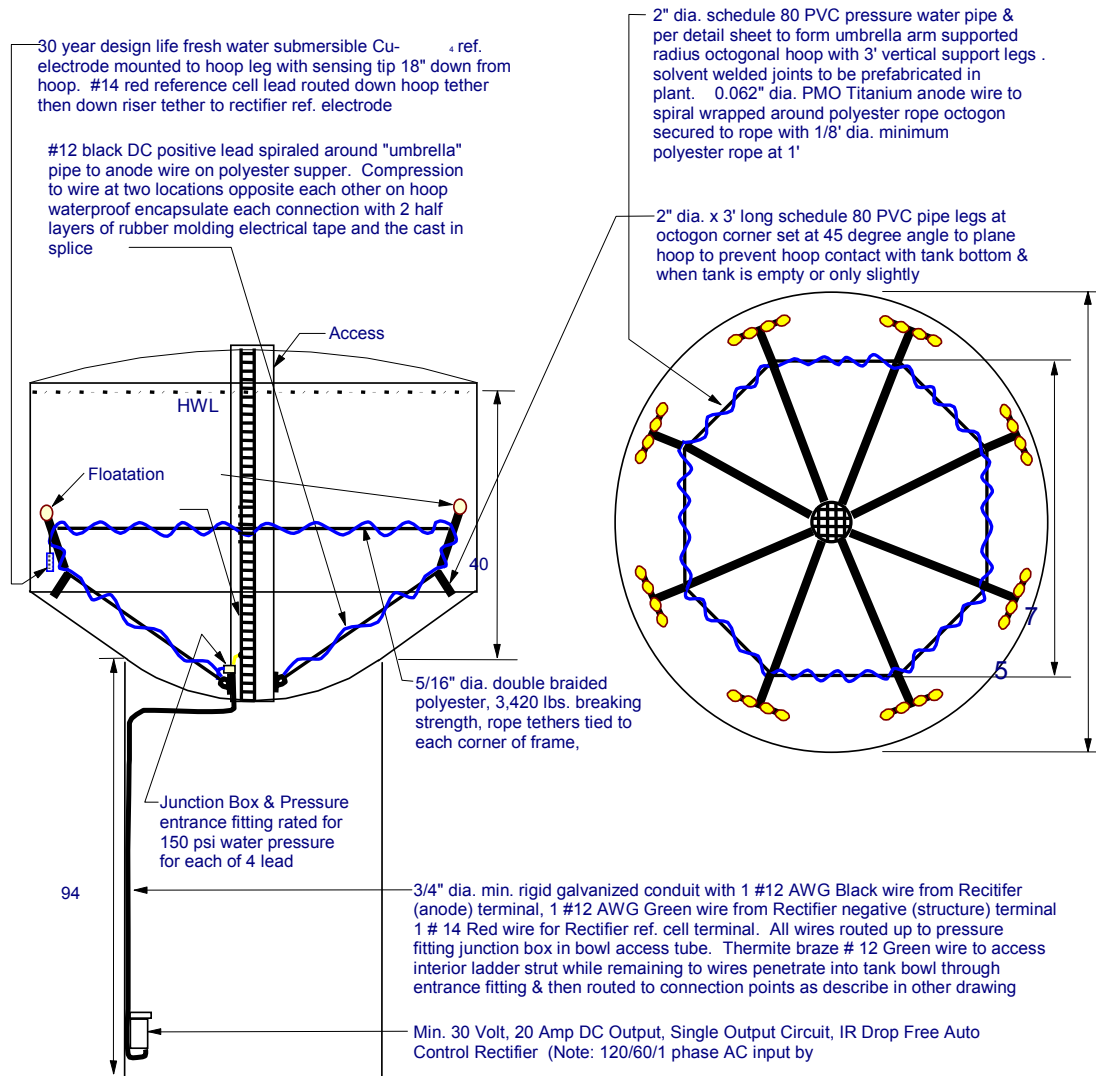
Driving time: 17 minutes

Appendix C: Fort Drum Ice-Free CP System Design

Ice-Free CP System Design Details

Ice Resistant Anode Design (No Riser Anode) 1MM Gallon HydroPillar Water Storage Tank with 20" Dia. Wet Riser Fort Drum, New York USA CERL-DMB Contract No. DACA42-00-P-0289 Prepared by James B. Bushman, P.E. -- Principal Corrosion Consultant Bushman & Associates, Inc. -- Medina, Ohio 44256 USA

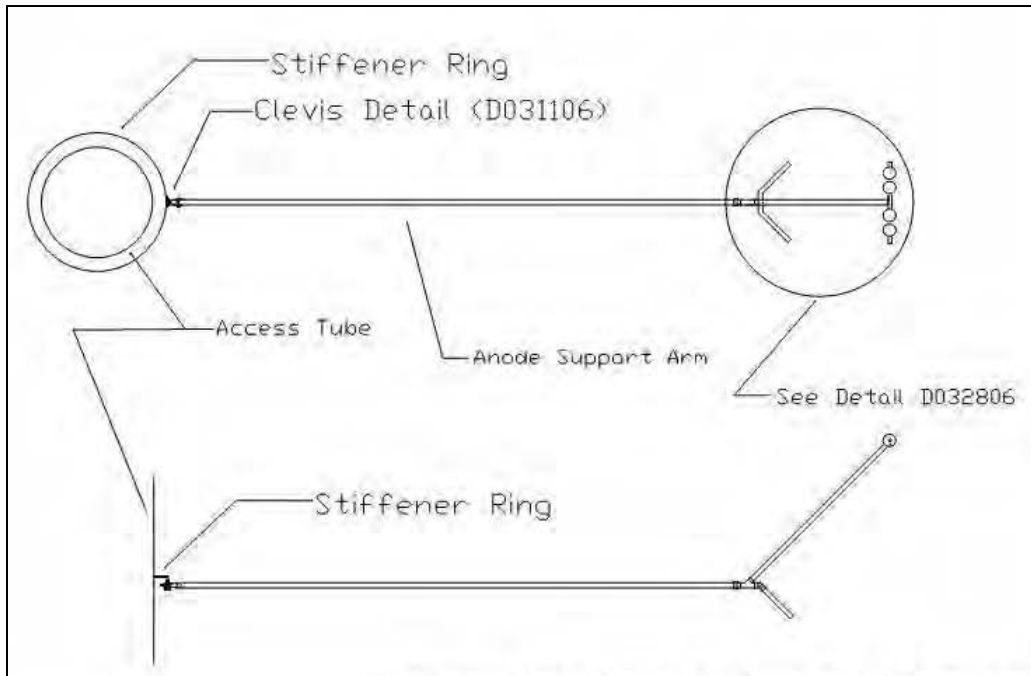
Tank Style	Crown Roof Hembo with Wet Riser
Straight Shell Tank Bowl Dia.	74.0 Feet
Straight Shell Tank Range in Head	40.0 Feet
Wet Riser Dia.	1.8 Feet
Wet Riser Height	125 Feet
Coating Efficiency (Initial)	99% Percent Surface Area Effectively Coated when System Installed
Coating Efficiency (Final)	50% Percent Surface Area Effectively Coated after 20 Years
Max. Water Resistivity	4,233
Tank Bowl CP Current Density	2.5 mA/Sq. Ft. of Bare Submerged Steel Surface Area
Tank Bowl Submerged Surface Area	13,600 Sq. Ft. (Note: Area = cylinder area ($\pi d^2 h$) + hemisphere area ($2\pi r^2$))
Max. Bowl Current Required at 20 Yrs.	17.00
Design Safety Factor	25%
Bowl Design Current Capacity	21.25
Bowl Anode Hoop #1 Dia.	52 Feet
Bowl Anode Hoop #2 Dia.	n/a
Bowl Anode Hoop #3 Dia.	n/a
Bowl Anode Depth Below HWL	24.0
Riser Anode Length	0 Feet
Wet Riser Surface Area	0
Tank Riser CP Current Density	3.0 mA/Sq. Ft. of Bare Submerged Steel Surface Area
Max. Riser Current Required at 20 Yrs.	0.000
Design Safety Factor	25%
Bowl Design Current Capacity	0.00
No. of Supplementary Riser Anodes	1
Platinum Anode Coating Material	Std Weight Precious Metal Oxide (Ceramic) Coated Copper Cored Dual Extruded Titanium/Niobium Wire for both Bowl & Riser Anodes
Copper Cored Copper Cored Niobium-Titanium PMO Standard Duty Coated Anode Life	2 ampere years/Lin. Ft.
Platinum Anode Diameter	0.0625 Inches
Resistance of Bowl Anode	1.73 Ohms
Resistance of Double End Feed Riser Anode	0.00 Ohms
Min. Resistance of Rheostat Used in Dual Circuit Rectifier within 2nd Circuit to Feed Riser Anodes	0 Ohms
Min. Wattage Capacity of 1 Ohm Rheostat Used in Dual Circuit Rectifier within 2nd Circuit to Feed Riser Anodes	0 Watts
Rectifier Minimum DC Amperes	22 Amps
Rectifier Minimum DC Volts	37 Volts
Minimum Calculated Anode Life (Bowl)	38.4 Years (Based on Average $I = 1/2$ Max. I @ 20 Years)
Minimum Calculated Anode Life (Riser)	n.a. Years (Based on Average $I = 1/2$ Max. I @ 20 Years)



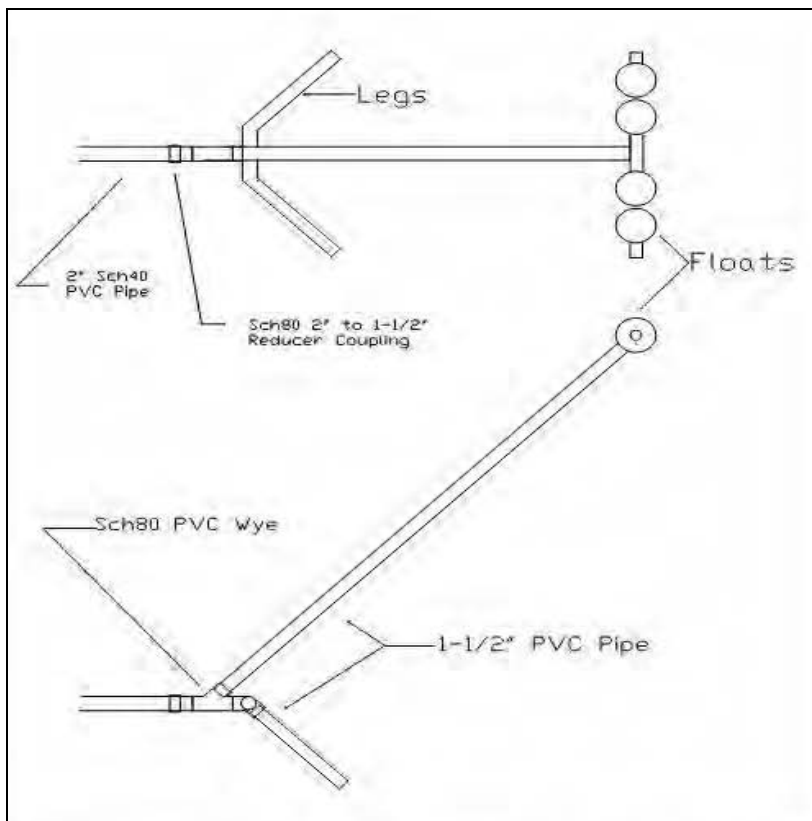
BUSHMAN &
CORROSION CONSULTANTS
P. O. Box 425 Medina, Ohio 44256
Phone: (330) 769-3694 Fax: (330) 769-2197

Scale:	NONE
Designed by:	JBB
Date:	1-Jan-2006
Drawing No.:	SML-3422

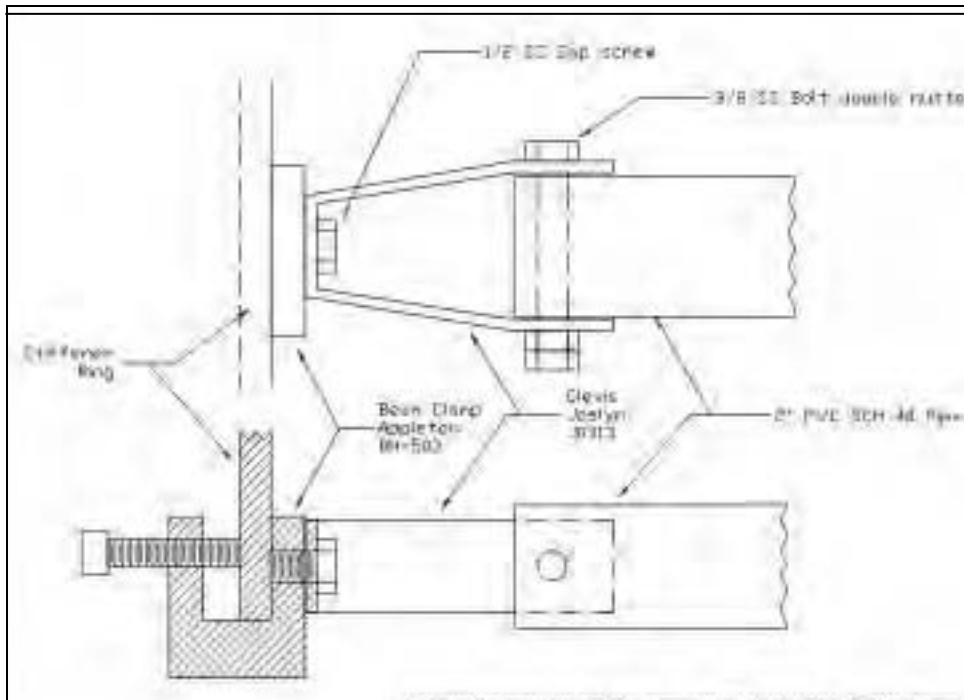
Ice Resistant Cathodic Protection System
1MM Gallon "Hydropillar"
Elevated Water Tank
Fort Drum, New York



Detail of Anode Support Arm



Detail of Anode Support Arm Float



Detail of Anode Anode Support Arm Clevis

Appendix D: Example Ice-Free CP System Contract Specification

**SPECIFICATION
for
Furnishing & Installing
Ice Damage Resistant
Impressed Current Cathodic Protection
in Two 1MMG Elevated Water Storage Tanks
Fort Drum, New York**

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Draft 0.91

Specification for Furnishing & Installing Ice Damage Resistant ICCP in 2 Elevated Water Tanks – Fort Drum, NY

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SECTION 1 - CATHODIC PROTECTION SYSTEM

1. GENERAL

This specification covers the requirements for furnishing and installing Impressed Current Cathodic Protection (ICCP) systems in two elevated water storage tanks at Fort Drum, New York. The systems shall be designed to minimize the probability of ice damage to the anode system within the tank bowl during winter months. The Cathodic Protection systems shall be installed to provide corrosion mitigation to the portions of the tank bowl submerged at all levels during normal operations and the interior of the tank wet riser(s) with a diameter greater than 30". This specification includes the technical requirements for the types of equipment to be provided in a ICCP system which shall be designed by the Cathodic Protection Contractor using the services of a qualified Corrosion Expert to provide a complete cathodic protection system design including this specifications and the system design drawings. The successful contractor must provide the design services of their Corrosion Expert to both design the system and to supervise the system installation and to test, energize and adjust the completed system installation. The Corrosion Expert, for the purposes of this project, is a person, who by reason of thorough knowledge of the physical sciences and the principles of engineering and mathematics, acquired by professional education and/or related practical experience, is qualified to engage in the practice of corrosion control through the application of ICCP to the interior submerged surfaces of Water Storage Tanks. In addition, this person must have NACE International Certification as a Cathodic Protection Specialist. The person must have a minimum of 10 years experience in this type work as either the design engineer or project installation superintendent of ICCP systems for at least twenty-five water tanks. The name and qualifications of the Corrosion Expert(s) must be certified and submitted by the successful contractor in writing for government approval to the Contracting Officer's representative prior to the start of the cathodic protection system installation.

It is the intent of these specifications to require the Contractor to design the system in its entirety and furnish, install, test and place into service the complete cathodic protection system for the water storage tanks. The system is to consist of all equipment and wiring necessary to produce a continuous flow of direct current from the anodes in the water electrolyte to the tank bowl and riser pipe (if more than 30" diameter) interior submerged surfaces to adequately and efficiently protect the metal surfaces against corrosion where the surfaces are in contact with the water. This is in addition to the protective coating in the tanks. The government has determined that the coating is currently at least 95% effective. For the purposes of system design confirmation, the contract shall assume that the coating will remain at least 75% effective at the end of the ICCP system design life of 20 years and the maximum current density required for effective cathodic protection is 2.5 milliamperes per square foot of submerged bare steel surface. In addition, the water resistivity within both tanks is approximately 4,500 ohm-cm. The contractor will provide, prior to system installation, detailed design confirmation calculations, installation drawings including details and bill of materials lists for the cathodic protection system to be installed. The submittals shall provide sufficient detail to confirm compliance of the proposed equipment with the intent of these specifications and shall include details on the ICCP anodes including pipe and rope

support system, automatically controlled rectifier power supply, terminal boxes, pressure entrance fittings, DC conductors, conduit and reference electrodes including their integral lead wire to be installed for corrosion control on the submerged surfaces of the tanks. The contractor furnished materials list, installation drawings and design review calculations must be approved by the Contracting Officer's representative prior to purchasing, delivering or installing any of the cathodic protection system. These specifications together with the approved materials list, design calculations and drawings shall provide the minimum requirements of this contract. The cathodic protection system shall be furnished complete and in operating condition as further defined later in this specification.

1.1. References

1.1.1. The following publications, referred to hereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto. In all cases, the contractor shall use the latest edition of the reference documents. If the Contractor desires for any reason to deviate from, or utilize publications other than those designated below, he shall submit to the Contracting Officer's representative for review and approval the requested deviation and/or the publication which he proposes to use. This submission shall clearly state the requested deviation and the reasons for it. When the Contractor proposes to use publications other than those listed below, he shall submit a copy of the proposed publication(s) including a complete comparison and cross-reference in sufficient detail to prove compliance to the applicable portions of the publications referred to herein and listed below.

1.1.2. Federal Specifications.

TT-E-485F -- Enamel, Semi gloss, Rust-Inhibiting Type II

TT-E-489F -- Enamel, Alkyd, Gloss (for Class A Exterior and Interior Surfaces)

TT-P-641-G -- Primer Coating; Zinc Dust-Zinc Oxide (for Galvanized Surfaces)

1.1.3. Federal Technical Reports.

ETL 1110-9-10(FR) – Cathodic Protection Systems Using Ceramic Anodes,
January 1991

1.1.4. Federal Technical Manuals

TM 5-811-7 – Electrical Design, Cathodic Protection, April 1985

1.1.5. American National Standards Institute (ANSI) Standards.

ANSI C80.1 -- Rigid Steel Conduit - Zinc Coated

1.1.6. American Society for Testing & Materials (ASTM) Standards

A36/A36 -- Standard Specification for Structural Steel

A518-80 Gr.2 -- Corrosion-Resistant-High Silicon Iron Castings

D1248-00a -- Standard Specification for Polyethylene Plastics Extrusion Materials
For Wire and Cable

D1785 -- Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe,
Schedules 40, 80, and 120

D1784-99a -- Standard Specification for Rigid Poly(Vinyl Chloride) (PVC)
Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC)
Compounds

Specification D2564-96a -- Standard Specification for Solvent Cements for
Poly(Vinyl Chloride) (PVC) Plastic Piping Systems

F1740-96 -- Standard Guide for Inspection of Nylon, Polyester, or Nylon/Polyester
Blend, or Both Kernmantle Rope

1.1.7. American Water Works Association (AWWA)

AWWA D104 – Automatically Controlled Impressed-Current Cathodic Protection
for the Interior of Steel Water Tanks

AWWA C652 – Standard for Disinfection of Water-Storage Facilities

AWWA D100 – Standard for Welded Steel Tanks for Water Storage

AWWA D102 – Standard for Painting Steel Water-Storage Tanks

AWWA D103 – Standard for Factory-Coated Bolted Steel Tanks for Water
Storage

1.1.8. NACE International (formerly the National Association of Corrosion Engineers)
Recommended Practices

RP0388 – Impressed Current Cathodic Protection of Internal Submerged
Surfaces of Steel Water Storage Tanks

TM0497 -- Measurement Techniques Related to Criteria for Cathodic Protection
on Underground or Submerged Metallic Piping Systems

1.1.9. National Electrical Manufacturer's Association (NEMA) Standards.

AB I -- Molded Case Circuit Breakers and Circuit Switches

FB 1 -- Fittings, Cast Metal Boxes and Conduit Bodies for Conduit and Cable
Assemblies

FU 1-86 -- Low-Voltage Cartridge Fuses

ST 1 -- Specialty Transformers (Except General-Purpose Type)

ST 20 -- Dry-Type Transformers for General Purpose Application

TC 2 -- Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80)

WC 3 -- Rubber-Insulated Wire and Cable for the Transmission and Distribution of
Electrical Energy

WC 5 -- Thermoplastic-Insulated Wire and Cable for the Trans mission and
Distribution of Electrical Energy

1.1.10. National Fire Protection Association

NFPA 70 -- National Electrical Code

1.1.11. NSF International

NSF-61 -- Certified Drinking Water System Components

1.2. Contract Bidding, Measurement and Payment

- 1.2.1. This contract will be based solely on the Lump Sum Bid of the successful bidder for all work required under this contract. Lump Sum Payment will be made upon successful completion of the work as specified. No partial payments are authorized nor will partial payments be made on this project.

1.3. SYSTEM DESCRIPTION

- 1.3.1. General Description -- The Contractor is to confirm system design, furnish, install, test and place in service a complete cathodic protection systems for two (2) - 1,000,000 gallon "*Fluted Column*" elevated water storage tank (NOT including riser pipe). The system shall consist of all equipment, wiring, and wiring devices necessary to produce a continuous flow of direct current from the anodes in the water electrolyte to the submerged steel surfaces of each tank's bowl and the riser pipe of the 1,000,000 gallon tanks to adequately and efficiently protect the surfaces of the metal structures against corrosion where their surfaces are in contact with the water. This is in addition to the protective coating on the tanks. The contractor must provide, prior to system installation, detailed design calculations, construction drawings, bill of materials lists and drawings of the cathodic protection system. The drawings shall detail the system installation including arrangement and locations of all anodes and floatation support system, pressure entrance fittings and terminal boxes, conduit routing and test facilities to be installed for corrosion control on the submerged surfaces of the gates. The contractor furnished materials list, design calculations and construction drawings must be approved by the Contracting Officer's representative prior to purchasing, delivering or installing any of the cathodic protection system. The specifications herein together with the approved materials list, design calculations and drawings shall provide the minimum requirements of this contract. The cathodic protection system shall be furnished complete and in operating condition as further defined later in this specification.
- 1.3.2. Performance Requirements – The system shall be final tested and adjusted such that the cathodic protection system is providing corrosion control for the submerged surfaces of the water storage tanks in accordance with the following paragraphs (ref. Section 6.2.1 of NACE International Recommend Practice RP-0388).
- 1.3.2.1. A negative polarized tank-to-water potential of at least 850 mV relative to a saturated copper/copper sulfate reference electrode (CSE).
- 1.3.2.2. The above criteria must be achieved without the polarized potential exceeding minus 1100 millivolts at any location.
- 1.3.2.3. Determination of this polarized potential shall be made with the cathodic protection system in operation. Correction shall be made for IR drop using "instant-off" potential measurements (all operating cathodic protection systems influencing the reading must be simultaneously interrupted). Where portable meters are used to take these measurements, they shall be of the digital type and either the "minimum" potential automatically recorded by the Fluke Model 865/867 or Extech MultiScope 381265 digital meter after ½ to 1 second interruption of the rectifier current shall be interpreted as the "instant-off" reading.

1.4. SUBMITTALS

1.4.1. Detail Construction Drawings. Within 30 days after receipt of notice to proceed, and before commencement of any work, 6 copies each of detailed construction drawings of the proposed cathodic protection system installation, proposed bill of materials, and contractor design calculations shall be submitted for approval. The drawings shall provide dimensions and show anode arrangement for both elevated water storage tanks including details of the proposed PVC pipe floating support system, rectifier details and locations including automatic control system, pressure entrance fitting & terminal box details and locations, mounting details, wiring diagram, and any other pertinent information considered necessary for the proper installation and performance of the system.

1.4.2. Approval of Materials and Equipment. Within 30 days after date of receipt of notice to proceed and before commencement of installation of any materials or equipment, the Contractor shall submit for approval a complete list in triplicate of materials and equipment to be incorporated in the work. The list shall include cuts, diagrams, and such other descriptive data as may be required by the Contracting Officer's representative. Partial lists submitted from time to time will not be considered. As a minimum, the submittal shall include the following:

1.4.2.1. Water resistivity as measured from sample obtained from site water department.

1.4.2.2. Complete system design calculations which, as a minimum, shall be similar to that provided in USACERL Technical Report FM-95/05 including calculations for total current required for each bowl and riser pipe, each anode circuit resistance, rectifier current and voltage output requirements and life for each anode configuration within each system.

1.4.2.3. Complete list of materials for all cathodic protection system components including all replaceable components in the rectifier units, terminal boxes, pressure entrance fittings, PVC anode floatation system components including solvent welding adhesive, tethering rope and anodes materials with mounting equipment including part numbers and source name, address and phone number for each component.

1.4.2.4. Conductor types and sizes including copper grade, number of strands, insulation, and resistance for each wire type and size to be used.

1.4.2.5. Anodes, layout of anodes, and detailed description of anode installation procedure.

1.4.2.6. Layout of rectifiers and anode terminal boxes, rectifier and terminal box details including method of control, wiring diagram and schematic, output measurement means, cabinet materials and construction, ammeters and voltmeters, shunt resistors, variable resistors, and AC & DC lightning and surge protection.

1.4.2.7. Detailed drawing of PVC pipe hexagonal anode support hoops and tethering systems including all components.

1.4.2.8. All connections, supports, and seals for conductors, conduit, and plastic and steel conduit.

1.4.2.9. All watertight connections and connection protection means.

1.4.2.10. Special details.

1.4.2.10.1. Certified experience and qualification data of installing firm, as outlined in paragraphs 1.5.1.

1.4.2.10.2. Certified Corrosion Expert(s) qualifications for all personnel who may be used to fulfill this position on the project, as outlined in paragraphs 1.5.2.

1.4.2.11. Weekly, Monthly and Annual Test Procedure to be part of the operations and maintenance instruction manual. This test plan shall conform to all applicable NACE International Recommended Practices.

1.4.2.12. Anode wire details including wire to power feed splice details and means for fastening to PVC floatation hoop.

1.4.2.13. All system installation and energization measurement and test data in tabulated form within two weeks after completion of system commissioning by the contractor's Corrosion Expert.

1.4.2.14. All Contractor identified discrepancies in the design or any change proposals with sufficient details for complete evaluation by the Contracting Officer's representative.

1.4.3. Except for items 1.4.2.12 above, all submittals for the work covered in this section shall be made at one time as a single submittal in order to demonstrate that the items have been properly coordinated and will function properly as a unit. A notation shall be made on each submittal as to the item's specific use, either by a particular type number referenced on the drawings or in the specifications, or by a description of its specific location. Except for items 1.4.2.12 above, no work shall begin until the Contracting Officer's representative has approved all submittals.

1.5. QUALIFICATIONS

1.5.1. The cathodic protection system installation, including all testing, energizing and placing of system in service, shall be performed by an organization that has had a minimum of 5 years experience in this type of work. The Corrosion Expert whose credentials meet or exceed those provided for in Section 1.5.3 shall supervise the installation and testing of this system. Installation of the cathodic protection system will also be witnessed by the Contracting Officer's representative. The contractor shall provide certified information with their submittals evidencing their compliance with this organization experience requirement.

1.5.2. The Contractor shall provide the services of Corrosion Expert to confirm the system design, supervise installation, test and final adjust the miter gate cathodic protection system for operation in accordance with these specifications. He shall inspect all work associated with the system installation, shall certify all work prior to system energization and shall be present and participate in all system testing and final adjusting.

1.5.3. "Corrosion expert", for the purposes of this project, is a person, who by reason of thorough knowledge of the physical sciences and the principles of engineering and mathematics, acquired by professional education and/or related practical experience, is qualified to engage in the practice of corrosion control through the application of ICCP to the interior submerged surfaces of Water Storage Tanks. The person must have a minimum of 5 years experience in this type work as either the design engineer or project installation superintendent of ICCP of water tanks.

1.6. DELIVERY, STORAGE AND HANDLING

- 1.6.1. Delivery of all system components shall be made by the contractor at time of system installation. All storage of materials shall be the sole responsibility of the contractor and no on-site storage facilities will be provided.

1.7. WARRANTY

- 1.7.1. A One Year Warranty shall be provided by the Contractor on each ICCP system including all components furnished under this contract. For existing water storage tanks, this one year warranty will begin once the system has been furnished and installed complete and final tested and adjusted for operation. For new water storage tanks, the warranty shall begin 90 days after the system is installed complete and is ready for operation or the system has been final tested and adjusted for operation, which ever comes first.

1.8. MAINTENANCE

1.8.1. Maintenance Service

Maintenance service shall be provided by the contractor during the One Year Warranty period and for an additional four (4) years including all annual maintenance services as detailed in section 8.3.2 of NACE International Standard RP0388.

PART 2 CATHODIC PROTECTION SYSTEM EQUIPMENT

2. **General:** All cathodic protection system materials and equipment furnished shall be designed for a minimum 20 year service life when operating at the system maximum rated output. The components to be used shall be based on the contractor's Cathodic Protection System Specialist's design which shall be in accordance with these specifications

2.1. Direct Current Cables.

2.1.1. Anode Lead Cables.

- 2.1.1.1. Direct current cable from the pressure entrance fitting inside the tank to each anode feed shall consist of 7-strand No. 8 AWG stranded copper wire with type RHW-USE Style RR hypalon insulation in accordance with NEMA WC-3. Each anode lead shall be continuous without splices from its point of connection at the pressure entrance fitting to the anode. The cable-to-anode connection shall be assembled by the manufacturer and the area shall be sealed with a waterproof epoxy. Cable-to-anode contact resistance shall be 0.003 ohm maximum and shall not be cut or spliced within the anode or assembly and must be routed without splicing to the tank pressure entrance fitting.

2.1.2. Rectifier Cabinets and Inter-Terminal Connection Cables.

- 2.1.2.1. One conductor shall be included for each dc plus (+) circuit and one conductor for each negative (-) connection. Each cable shall be continuous

without splices from its point of connection in one terminal cabinet to its point of connection in the other terminal cabinet.

2.1.3. Cable in Conduit.

- 2.1.3.1. Cathodic protection cables in conduit runs from the Rectifier to the pressure entrance fitting shall consist of soft drawn copper conductors with Class B stranding and THW or THWN covering serving as both insulation and jacket. AC power adjacent to the Rectifier location will be provided by others from a separate 20 ampere capacity, 115/60/1Ø circuit in a fused disconnect box within 2 feet of the approved Rectifier location.

2.2. Rectifiers and Auxiliary Equipment.

- 2.2.1. General. An automatic potential control rectifier unit shall be provided for each water tank. While the type of control and electronics specified herein represent the current stat of the art, it is not intended to deny the use of new technology which meets and exceeds the performance characteristic of the rectifiers specified herein. If the contractor wishes to use a different type of unit, complete information on the type of system with all details necessary to evaluate the functional equivalency to the specified unit must be submitted to the COTR for this project at least 60 days prior to proposed installation date for the proposed alternative unit. The cathodic protection system power circuit must also be equipped with manual adjustment via a step-down transformer with secondary taps for output adjustment, primary circuit breaker, rectifier transformer, rectifier, secondary fuses, and rectifier terminal panel. The rectifier units shall be located at the bottom of each tank tower within the fluted column base of each 1MMG tank.
- 2.2.2. Cabinets. The rectifier cabinet shall house the rectifier transformer, rectifier stacks, circuit breaker, terminals, and the control and instrument panel. The cabinet shall be designed such that the rectifier equipment specified above can be installed in the lower section of the cabinet with the step-down transformer in the upper portion. Cabinets mounted indoors shall be convection air cooled constructed of 14-gauge minimum powder coated sheet steel while units mounted outdoors shall be minimum 16 guage sheet stainless steel, ASTM grade 304. All cabinets shall be designed for use outdoors, NEMA 3R or NEMA 4X and appropriate structural shapes shall be used in the construction of the cabinet to provide rigidity and to prevent bending or flexing of the cabinet while being transported. Louvers for air-cooled units shall be provided in the hinged doors and on the sides of the cabinets for ventilation. All ventilation openings shall be covered with ASTM grade 304 stainless steel insect screens arranged so as to be easily replaceable. Access to the front of the unit and to each side shall be provided. All doors shall be hinged designed to allow easy removal of all doors for unit servicing and shall be provided with a hasp and lock for padlocking.
- 2.2.3. Mounting. The rectifier cabinet shall be mounted on the structures at approved locations at the general locations indicated above and shown on the drawings. Welding mounting brackets made from the same material as the cabinet shall be accomplished at the factory before finishing.
- 2.2.4. Circuit Breakers and Fuses. Protection from overloads on the input shall be accomplished by molded case fully magnetic circuit conforming to NEMA Pub. No.

AB1 breakers on the incoming power lines. The circuit breaker shall be sized for 120V/60Hz/1 ϕ AC power input. The circuit breakers shall hold at 100% of load and may trip between 101% and 125% of rated load. It must trip at 125% of rated load or higher. The trip point must be unaffected by changes in ambient temperature. The breaker shall be provided with instantaneous and inverse time trips. Cartridge-type fuses of suitable capacity for the rectifier DC circuits conforming to NEMA FU-1 with suitable fuse holders shall be provided in each leg of the dc positive and negative circuit(s).

- 2.2.5. Rectifier Transformers. The rectifier transformer shall be two- winding, convection air-cooled, with a primary operating voltage of 120volts, single phase, and shall conform to the requirements of NEMA ST-1. The transformer secondary shall be provided with 5 "coarse" and 5 "fine" taps on each dc circuit, to permit variations of the dc output voltage in 25 uniform increments of the rated output voltage, from zero to a maximum rated voltage of volts. Voltage steps shall be adjustable by rotating solid brass tap bars. Each control shall be identified by suitable permanent, engraved marking such as "coarse" or "fine" and shall have an arrow to indicate the type and direction of adjustment. Individual steps of adjustment shall be marked with numbers in consecutive order for fine control and with letters in alphabetical order for coarse control. All primary alternating current terminals shall be mounted behind the panel. The coils of all transformers manufactured for cathodic protection use shall be dipped in preheated varnish and baked dry for maximum moisture and corrosion resistance. The transformer efficiency shall be not less than 95%. The dielectric strength of all insulation materials shall withstand 2000 volt (RMS value at 60 Hz) applied for one minute between the winding and the core. The impregnating varnish used for moisture proofing of the transformer shall meet the standards for 155 o C operation when tested according to AIEE transformer test procedures. The magnetic core losses shall not exceed 1 watt per pound at 60 Hz when tested in accordance with ASTM Specification A 34.
- 2.2.6. Rectifier stacks. Rectify elements shall be silicon diodes and silicon controlled rectifier elements (SCR's) connected in such manner as to provide full-wave rectification. All silicon elements shall be protected against over-voltage surges by metal oxide varistors (MOV's). The MOV's must fire (conduct to ground) before the voltage surge reaches the peak inverse voltage (PIV) rating of the silicon elements used in the rectifier stack. All Silicon elements shall be rated at a minimum of 600 peak inverse volts. Heat sinks shall be sized to keep diode junction and case temperatures from exceeding 100 o C under 45 o C ambient temperature conditions.
- 2.2.7. Automatic Control. Automatic Constant Potential Control for the primary (tank bowl) circuit shall be provided for the DC output of each rectifier. The controller shall be housed integrally within the rectifier on a "plug-in" printed circuit card to facilitate easy replacement. The automatic controller shall be of completely solid state design and shall be capable of automatically maintaining the tank-to-water potential at (-) 900 millivolts with respect to a Cu-CuSO₄ reference electrode with an accuracy of ± 25 millivolt from the system set potential. The potential measured and controlled by this automatic control circuitry shall be a polarized potential value, free of IR-Drop caused by the CP system DC output current.

- 2.2.8. The potential set point shall be adjustable by a rheostat with a sufficient number of turns to allow adjustment of and to hold the desired potential within ± 5 mV from at least 800 mV to 1200 mV DC. This setting must provide a stable signal to the automatic potential control circuitry such that the output is maintained at the selected potential value. The rheostat shall be provided with a lockable, calibrated adjustment knob. The electronics necessary for providing this constant current control shall be mounted on a single printed circuit card which is rack mounted for easy repair and replacement.
- 2.2.9. Secondary output circuit. None required
- 2.2.10. Power Carrying Connections. All power carrying connections including their associated nuts and washers shall be solid copper or brass with a coating of either silver or electro-less nickel to prevent oxidation of these connectors. Any power carrying compression connectors shall also be silver soldered.
- 2.2.11. Ammeter, Voltmeter and Potential Meter. Either separate DC ammeter, voltmeter and structure potential meters or a combination metering system of the semi flush, digital type, conforming to the applicable requirements of ANSI C39.1, shall be provided. Instruments shall have a resolution and accuracy as follows:
 - 2.2.11.1. Voltage Meter Resolution and Accuracy: $0.1 \text{ V} \pm 0.2 \text{ V}$.
 - 2.2.11.2. Ammeter Resolution and Accuracy: $0.1 \text{ A} \pm 0.2 \text{ A}$.
 - 2.2.11.3. Potential Meter Resolution: $1 \text{ mV} \pm 3 \text{ mV}$
- 2.2.12. Current Monitoring Shunt. A separate current monitoring shunt resistor shall be provided on the rectifier unit face plate for each dc output circuit to facilitate using an external digital milli-voltmeter to confirm the current output displayed by the unit ammeter. This shunt resistor shall have a calibrated accuracy of $\pm 1\%$ and shall have a 1ampere/millivolt drop rating.
- 2.2.13. Potential Meter Switches. A switch for displaying either the "instant-off" to "set point" potential on the Potential Meter shall be lever action sealed toggle, quick make double pole type switch. The switch shall be spring loaded so that it is normally connected to provide the structure "instant-off" potential and momentarily connected to the "set point" potential.
- 2.2.14. Reference Cell 1 and 2 Meter Switches. A switch for displaying either the "instant-off" to "set point" potential when using Reference Cell 1 or 2 on the Potential Meter shall be lever action sealed toggle, quick make double pole type switch. The switch shall be allow either one of the reference electrodes to be read and used as the control reference electrode.
- 2.2.15. Control and Instrument Panel. The control and instrument panel shall be of the dead-front type and shall be installed in the rectifier cabinet. Primary connection shall be made by means of a panel-mounted terminal block with screw connection protected by a removable metal or molded plastic cover. Incoming power lines shall be terminated in such a manner as to prevent accidental contact by personnel using the rectifier.
 - 2.2.15.1. Tap Bars: Tap bars serving the rectifier transformer secondary adjustment shall be permanently identified by means of engraving on the non-metallic control panel face plate denoted "coarse" and "fine" and shall have the

individual tap positions identified by letters, "A", "B", "C", etc., and numerals, "1", "2", "3", etc., respectively.

- 2.2.15.2. DC Output Terminals: Rectifier dc output terminals shall be identified by means of engraving on the non-metallic control panel face plate indicating polarity of the terminal and point of connection to the system, i.e., "(+) BOWL ANODE", "(+) RISER ANODE" and "(-) STRUCTURE".
- 2.2.15.3. System Potential and Potential Set Point: Toggle Switch labels to identify System Operating "Instant Off" Potential and System "Set Point" Potential.
- 2.2.15.4. Reference Electrode 1 and 2. Toggle Switch labels identifying selection of either reference electrode 1 or 2 for operation of the system.
- 2.2.15.5. Faceplate mounted current output measuring shunt resistance and current values
- 2.2.15.6. All other components on the rectifier panel face plate shall be identified by means of engraving on the non-metallic control panel face plate.
- 2.2.16. Anode and Structure Ground Cable Leads. Anode and structure cable leads shall be identified near their respective terminals in the rectifier cabinet by means of plastic sleeve or tag identifying the wire as the anode lead. They shall be of sufficient length so that splicing between the structure entrance fitting (anode) or ground (tank bowl) is not necessary. No splices of the anode or reference lead wires will be permitted within conduit runs or between the anode and the anode pressure entrance fitting or system negative ground which shall be made near the pressure entrance fitting.
- 2.2.17. Surge Arresters. MOV surge arresters shall be provided for all AC & DC power circuits. In addition, for AC voltages above 120-volt, a single pole valve-type surge arrester shall be used for each input line. It shall be located ahead of the ac breaker feeding the rectifier transformer. Surge arresters shall be rated for continuous load currents up to 10 () amps minimum and shall limit the voltage to 200 volts peak. The response clamping activation time shall be 5 nanoseconds maximum.
- 2.2.18. Wiring Diagram. A complete wiring diagram of the rectifier unit showing both the ac supply and the dc outputs to the resistor and anode terminal cabinets shall be encased in clear rigid plastic and mounted on the inside of the rectifier cabinet door. All components shall be shown and labeled.

2.3. Conduit and Fittings.

- 2.3.1. Nonmetallic Conduit. Nonmetallic conduit shall be type 80, extra heavy-wall, PVC, rigid-plastic conduit. Use of non-metallic conduit shall only be used where prior approval for its use is granted by the base Department of Public Works.
- 2.3.2. Rigid Metal Conduit. Rigid metal conduit shall conform to the requirements of ANSI C 80.1, and shall be of the size indicated on the drawings. The conduit shall be either aluminum or galvanized steel with galvanizing on both inside and outside using the hot-dip method. Flexible metallic conduit may be used for runs less than 8 feet in length at either terminus of a conduit run.
- 2.3.3. Conduit Fittings and Outlets. Conduit fittings and outlets for rigid metal conduit shall conform to the requirements of NEMA FB 1.

2.4. Pressure Entrance Fitting

- 2.4.1. Each tank shall be provided with a pressure entrance fitting suitable for transferring the DC power and ground feeds and reference electrode sensing wire within each tank to the wiring in conduit to the corresponding terminals in each rectifier. The fitting shall be pressure tight for 48 hours (no water leakage) when subjected to a continuous pressure of 150 PSI. The manufacturing shall submit test data certified by a registered professional engineer that the fittings to be used in these installations have been tested and passed this pressure test.

2.5. Long Life Reference Electrodes

- 2.5.1. Each CP system shall be equipped with a 15 year minimum design life continuous immersion saturated, gelled copper-copper sulfate (Cu-CuSO₄) or silver-silver chloride reference electrode (Ag-AgCl). It shall be provided with antifreeze protection to at least (-)50 F and shall be factory fabricated with RHW/USE Type RR Hypalon insulated lead wire of sufficient length that no splicing will occur between the reference electrode and the pressure entrance fitting. The cell shall be equal to Electrochemical Devices, Inc. Belmont, MA Model IRA-AGG-LWxxx or IRA-CUG-LWxxx (xxx = lead wire length in feet) regular immersion reference electrode.

2.6. Impressed Current Anodes and Materials.

- 2.6.1. For details on various types of anodes, anode designs and typical anode configurations for preparation of project drawings, the Corrosion Expert designing the system shall refer to USACERL Technical Report FM-95/05 dated November 1994.
- 2.6.2. Ceramic Precious Metal Oxide Coated Anodes shall conform to the following requirements:
 - 2.6.2.1. Conductive Precious Metal Oxide Ceramic Coating – The electrically conductive ceramic coating shall contain a mixture consisting primarily of iridium, tantalum, and titanium oxides. Although the exact composition of the conducting layer can vary, the average composition shall generally be a 50/50 atomic percent mixture of iridium and titanium oxides with small amounts of tantalum. The coating resistivity shall be certified by the manufacturer to have an electrical resistivity of less than 0.002 ohm-centimeters, a bond strength to the substrate metal greater than 50 MPa, and a current capacity of 100 DC amperes per square meter of anode surface area when operated in an oxygen-generating electrolyte at 150 degrees F for 20 years.
 - 2.6.2.2. Anode Substrate Material – The anode substrate shall be 1/16" diameter wire fabricated from high purity ASTM B337 grade I or type II alloy titanium.
- 2.6.3. Anode Floation Tethering Rope.
 - 2.6.3.1. The tethering rope used to constrain the anode flotation ring in the correct orientation when the tank is filled with water shall be 5/16" diameter double braid 100% polyester fiber rope with a minimum new rope breaking strength of 3,400 pounds and a design working strength range of 285 to 684 pounds. It shall be constructed of a polyester braided cover over a polyester braided core. Absolutely no other alternative materials will be allowed for use on this project. Rope (twine) used to fasten the anode material to the PVC

floatation ring shall be of the same material except that it may be of single level stranded or braided type polyester having a minimum 1/8" diameter.

2.6.4. PVC Anode Floatation Pipe and Fittings.

2.6.4.1. PVC pipe, to be used as the anode support structure, shall be similar to that manufactured by Bristol Pipe, Inc. of Elkhart, Indiana, for potable water service. If the pipe is to be used as the primary floatation means, the pipe diameter must be a minimum of 3" diameter. The Pipe shall be Schedule 80 PVC minimum conforming to ASTM D-1785 and D-1784, AWWA C900 for Polyvinyl Chloride (PVC) Pressure Pipe.

2.6.4.2. PVC pipe fittings shall be Schedule 80 pressure fittings similar to that manufactured by NIBCO, Inc. of Elkhart, Indiana conforming to ASTM Standard D1784 meeting Class 12454-B, ASTM Standard D-2466, AWWA C900 for Polyvinyl Chloride (PVC) Pressure Pipe. All fitting and pipe shall be joined with PVC cement which conforms with ASTM D-2564.

2.6.5. Painting. All submerged steel components installed inside the tank bowl and riser shall be equivalent in protection to that used to coat the tank submerged surfaces, and shall be painted after any welding of the component to the tank. The welded area shall be cleaned to bare metal and painted in this same manner. The paint shall be of the same type used on the tank.

2.7. Spare Parts. One complete set of spare fuses for each rectifier shall be supplied.

2.8. Markings.

2.8.1. Rectifier Cabinets. Rectifier cabinets shall be identified by means of suitable engraved stainless steel plates attached either to the exterior or interior of the of the rectifier cabinet by means of bolts or screws. The interior identification shall provide the rectifier manufacturers complete name, address and phone number. The label shall also provide, as a minimum, the rectifier model number, serial number, AC current, voltage and phase input and DC current and voltage rated output capacity.

2.9. Construction Qualifications

2.9.1. The installation, including testing, shall be performed by an organization that has had a minimum of 5 years experience in this type of work. The installation and testing of this system shall be supervised by the Corrosion Expert previously defined in this specification and shall be the same person approved by the original submittal package.

2.10. Quality Control.

2.10.1. General. The Contractor shall establish and maintain quality control for all operations to assure compliance with contract requirements and shall maintain records of his quality control for all construction operations, including, but not limited to, the following:

- Design
- Materials.
- Assembly and workmanship.

- Installation.
- Testing.

2.10.2. Reports. The original and two copies of these records and all tests, as well as corrective action taken, shall be furnished at the end of the system installation to the Contracting Officer's representative.

2.11. Coordination and Verification of Site Conditions.

2.11.1. The locations of the elevated water tank structures to receive protection are available from the Contracting Officer's representative. The Contractor shall visit the premises and thoroughly familiarize himself with all details of the work and working conditions, shall verify existing conditions in the field, note the exact locations for materials and equipment to be installed on the gates for cathodic protection, and advise the Contracting Officer's representative of any discrepancies before performing any work. The cathodic protection systems shall be designed based on a water resistivity of 4500 ohm-centimeters and a total area 16,600 square feet in each 1,000,000 elevated tank (no protection to be provided in the small diameter risers) and a minimum coating efficiency of 75% at the end of its useful service life, a minimum current density requirement for effective cathodic protection of 0.0025 amperes/bare square foot of submerged steel and a 20-year life expectancy.

2.12. **Modification of Design.** No modifications to the design of the cathodic protection system as submitted by the contractor will be permitted once the original design is approved for installation without the express written approval of the Contracting Officer's Technical Representative. The minimum design requirements specified herein shall be met. All such proposed modifications shall be fully described and submitted to the Contracting Officer's representative for approval. The Contractor shall be responsible for the satisfactory performance of the complete systems that he furnishes. Modifications or changes proposed shall be identified as a "MODIFICATION" or "CHANGE" and shall be submitted to the Contracting Officer's representative for approval within 15 days after the need for such modification or change is determined.

PART 3 – CATHODIC PROTECTION SYSTEM INSTALLATION & COMMISSIONING

3. Installation & Commissioning

3.1. System Installation

General -- All materials, equipment, and labor necessary to provide a complete and workable cathodic protection system conforming to the drawings and specifications shall be furnished. All electrical work and materials shall conform to NFPA No. 70 and requirements specified herein. Rigid (RGS) conduit shall conform to ANSI C80.1 and shall, in addition, be either aluminum or zinc-coated (galvanized) steel both inside and outside by the hot-dip method. Fittings for rigid metal conduit shall conform to NEMA FB 1.

3.1.1. Wiring.

3.1.1.1. Wiring to a suitably sized AC disconnect switch will be provided by others to a point within 2 feet of the mutually agreed upon location for each rectifier unit. Wire and insulation of the type and sized specified previously in this specification and as shown on the drawings shall be installed between the rectifier cabinet and the tank pressure entrance fitting.

- 3.1.1.2. Wiring on the tank exterior or within the fluted column shall be installed in rigid galvanized steel conduit. Conduit installed on the tank ladder leg and balcony shall be fastened to the ladder or balcony struts in a manner that shall not interfere with climbing the ladder or using the tank balcony or roof access ladder. Each anode element shall have double end power input feed wire connections for redundancy and reductions of IR drop in the anode wire. Anode elements greater than 100 feet long shall have an intermediate power input feed wire connection to reduce IR drop in the anode wire. If the anode element is more than 200', an additional intermediate anode feed shall be provided to reduce IR drop in the anode wire. Each submerged anode or system ground power feed wire shall be provided with sufficient lead length, without splicing, to reach from the anode feed or ground connection to the pressure entrance fitting.

3.1.2. Ceramic Wire Tank Bowl Anode and Hoop Support Installation.

- 3.1.2.1. The anode hoop support system shall be fabricated and erected as shown on the submittal drawings prepared by the contractor's Corrosion Expert. The PVC plastic pipe hoop or strut anode support system shall be prefabricated and dry fit to facilitate easier installation within each tank bowl. Confirmation of Tank dimensions and suitability of the final hoop shape for its intended use within each tank are the sole responsibility of the contractor. Any scaffolding necessary to facilitate the final assembly of the hoop within each tank are the responsibility of the contractor. All installation work inside the tank bowl and riser must be done in a manner to prevent damage to the existing coating system inside the tank. The contractor must repair the coating wherever welding or other construction activities damage the coating, either within the tank or on the tank exterior, in a manner to restore the coating condition to the same condition that existed prior to the contractor's system installation activities.
- 3.1.2.2. The PVC plastic pipe strut or hoop support system must be fabricated using solvent welding glue as specified earlier in this document. Adequate ventilation must be provided to protect the workers health and to preclude accumulation of dangerous (explosive or flammable) concentrations of fumes from the glue solvent. The entire system is intended to serve as anode support system with integral floatation chamber for the 20 year system design life and therefore, the contractor must final air pressure test the completed assembly for 24 hours to assure there are no leaks within the system that could result in loss of buoyancy of the floating hoop system.
- 3.1.2.3. The plastic pipe manufacturers instructions for joining of the pipe shall be followed explicitly. No pipe joining shall be performed when ambient temperatures inside the tank are expected to fall below 8 degrees C (45 degrees F) within 24 hours after pipe joining. The PVC plastic pipe must be reamed both internally and externally to remove all burrs prior to permanent joining. Each pipe joint shall be thoroughly cleaned and then primed using a PVC primer made by the same manufacturer as the cement to be used for final joining of the pipe. The primer shall be applied to both joining services. Immediately thereafter, a smooth coat of cement shall then be applied to both joining surfaces and the pipe end inserted into the coupling to the full depth of the fitting. Immediately turn the pipe or fitting 1/8 to 1/4 turn to

insure an even spread of the cement being sure to finally leave the fitting and pipe in the correct orientation as shown on the drawings.

- 3.1.2.4. The polyester rope tethering system must be installed in a fashion to assure uniform lengths of tether, $\pm 1\%$, are provided to each corner of the hoop so that the hoop is restrained in a level position when the tank is filled and the tension on each corner of the octagonal hoop is similar.

3.1.3. Ceramic Wire Tank Riser Anode and Tension Rope Support Installation.

- ~~3.1.3.1. The ceramic coated titanium wire riser anode shall be supported within the tank wet riser of the _____ gallon elevated tank on a tensioned polyester support rope as shown on the drawings. The rope shall be pre-tensioned between porcelain ceramic strain insulators welded to the tank riser grate at the bottom of the bowl and riser tether support channel installed for this purpose in the bottom of the riser pipe. It shall prevent movement of the anode within the riser pipe during tank filling and emptying from. It shall be spiraled around the polyester support rope and fastened to the support rope at least every 1' using the same type polyester material so long as it is at least 1/8" diameter single or double braided rope or twine material.~~

3.1.4. Installation of Permanent Reference Electrodes

- 3.1.4.1. Permanent Reference Electrodes shall be mounted to the submerged exterior of the tank bowl access tube approximately 1' above the tank bottom and the tank access tube surfaces and on anode hoop support opposite the DC power entrance feed to the Anode which shall be connected to the #2 reference electrode terminal in the rectifier. It shall be securely fastened to permanently hold it in a position such that it will be 36" of the tank surface when the tank bowl is empty. The reference electrode wire shall be run down the tether opposite the power feed without splices to the pressure entrance fitting.

3.1.5. Rectifier Cabinet Installation.

- 3.1.5.1. The automatic IR drop free potential controlled rectifiers shall be bolt mounted at the location shown on the drawings. The support brackets to which the cabinet is bolted may either be welded or mechanically fastened to the tank structure. Neither installation shall interfere with the opening of the rectifier face and side panels or with using the tank access ladders.

3.1.6. Repair of Existing Work.

- 3.1.6.1. The work shall be carefully laid out in advance, and where welding, cutting, channeling, chasing, or drilling of the tank structure or other surfaces is necessary for the proper installation, support, or anchorage of the system components including penetration fittings, tether elements, cabinets, conduit, raceways, or other electrical or mechanical work, this work shall be carefully done, and any damage to the tank structure or equipment be repaired by skilled mechanics of the trades involved, at no additional cost to the Government.

3.2. System Commissioning

- 3.2.1. General. The Contractor's Corrosion Expert shall be on-site and supervise the following system energizing and commissioning tests. All energizing and

commissioning tests shall be obtained in the presence of the Corrosion Expert and shall be taken shall be recorded and submitted to the Contracting Officer's representative within 30 days following completion of the test. The Contractor shall give the Contracting Officer's representative 30 days advance notice of the date of the test so that a representative can be present. All instruments used in conducting the tests shall have been calibrated within the previous 11 months. Certification of his calibration shall be provided to the Contracting Officer's representative for approval.

3.2.2. System Component Circuit Resistance Measurement.

- 3.2.2.1. Within 1 week following the re-filling of the tank and prior to system energization, the resistance of each anode, reference electrode, system ground and reference ground shall again be measured and recorded using 4 separate test lead wires and a Nilsson Model 400 AC impedance meter or other similar AC impedance instrument acceptable to the Contracting Officer's representative. The measurement shall be made by disconnecting the component lead at the appropriate terminal in the rectifier unit cabinet and connecting two of the four AC impedance test leads individually to the lead wire. The other two AC impedance test leads shall be individually connected to the structure component to which the component is mounted or connected. Should the resistance between the lead wire and the structure (anode and reference elements must be immersed in water) be less than 25% or more than 150% of the calculated or expected resistance, the Contractor shall make the necessary corrections and/or modifications necessary to achieve the anticipated value(s).

3.2.3. Structure-to-Reference Cell Potential Measurements.

- 3.2.3.1. Following completion of the installation of the cathodic protection system and prior to placing the impressed current cathodic protection system in operation, structure-to-reference cell potential measurements shall be made. The testing equipment shall be made with a calibrated copper-copper sulfate reference electrode with waterproof connector to insulated test lead wire suitable for immersion testing and of suitable length so that no splices are necessary in the test lead wire and a high- resistance digital voltmeter, equal to Fluke Models 865 or 867 or Extech MultiScope 381265 digital meter. The copper-copper sulfate reference electrodes shall contain saturated reagent grade copper sulfate crystals in distilled water. Prior to first system energization, native "OFF" potential measurement shall be measured and recorded using the same meter and calibrated reference electrode to be used during system energization and adjustment. These native "OFF" potentials shall be measured and recorded at all the same locations required in paragraph 3.2.4.1.3

3.2.4. Rectifier Adjustment.

- 3.2.4.1. Rectifier adjustment shall be accomplished as follows:

- 3.2.4.1.1. All testing shall be performed on the tank when the tank bowl is filled to at least 90% of capacity. Adjust the automatic IR drop free potential controlled output of the rectifier so that the Polarized (IR drop free) tank-to-water potential measured using the installed permanent reference cell indicates that the negative potential has stabilized and maintains a

polarized potential of at least minus 0.85 volt and not more than 1.0 volts. Confirmation of the range of potentials maintained within the tank shall be accomplished by adjusting the rectifier "automatically maintained "set potential" to obtain the aforementioned "instant-off" potentials. Manual IR drop free confirmation measurements, using the specified digital meter and reference electrode, shall be made by interrupting the current output of the rectifier either manually or automatically using a minimum 90% "ON" and maximum 10% "OFF" interruption cycle. If more than one rectifier is energized at the same time, all such rectifiers must be interrupted simultaneously. The "OFF" time period shall not exceed 1 second. During this "OFF" period, the Fluke model 865 or 867 meter or Extech MultiScope 381265 digital meter shall be used to automatically read the polarized (IR drop free) protective potential on the structure during each interrupted reading. If any tank-to-electrolyte polarized potential readings measured are more positive than minus 850 millivolts or more negative than minus 1100 millivolts, the system shall be adjusted to shift the potentials so that all measure values are within this range.

3.2.4.1.2. Perform a complete structure-to-water potential survey of the submerged surfaces of the tank bowl and wet riser pipe as described below.

3.2.4.1.3. Locations of Structure-to-Reference Cell Potential Measurements

3.2.4.1.3.1. The reference cell shall be located in the water, 0.5 to 3 in. from the tank submerged surface. The reference cell connected with a waterproof screw coupled connector to a conductor on a reel. The cell shall be lowered to depths in the water as indicated below. The reference cell conductor shall be connected to the positive terminal of the digital voltmeter. A second conductor shall be connected from the tank structure to the voltmeter negative terminal. The measurement procedure required in paragraph 3.2.4.1.1 shall be repeated and recorded for each measurement location. Measurements shall be made every 3 ft horizontally from the center of the tank across the tank bottom, across and up curved or angled transitional surface and then vertically up the tank bowl side wall. If readings can not be made in these locations because roof access hatches to facilitate these measurement are not available, then a similar potential profile shall be made from the tank bottom along the bowl access tube to the high water line. These same measurements shall be made from the bottom to the top of any wet risers provided with cathodic protection.

3.2.4.1.4. Polarization Decay.

3.2.4.1.4.1. Polarization decay (or gain) criteria shall not be used to adjust the CP or confirm its performance on these coated elevated water storage tanks

3.2.5. Recording of Measurements.

3.2.5.1. All system component circuit resistances, structure-to-water potential measurements, including native potentials, and rectifier final set point and output values shall be assembled in computer generated tabular form using

Microsoft Excel or similar approved spreadsheet and submitted in six copies together with a copy of the data disk (3-12 floppy disks), with each location identified on the as-built drawings. The Contractor shall locate, correct, and report to the Contracting Officer's representative any unusual data or problems encountered during checkout of the installed cathodic protection system. Structure-to-water potential measurements are required on structures as necessary to affirm that protection has been achieved on all submerged surfaces of the elevated water tanks. All tests shall be witnessed by the Contracting Officer's representative and the completed test measurements data shall be submitted to him for his review and approval.

3.3. Guarantee.

- 3.3.1. The materials, equipment, and workmanship furnished under this section of the specifications shall be guaranteed for a period of 1 year from the date of acceptance. Prior to expiration of the warranty period, the Government will conduct a System voltage and current output test of the cathodic protection system including each anode output circuit as well as detailed "On" and "Instant-Off" structure to electrolyte potential measurements to determine if the system and equipment are performing in accordance with the plans and specifications and that no significant deterioration of the system or components therein has occurred during the first year of operation. The Contractor shall acknowledge responsibility under these guarantee provisions by letter, stating that the equipment, materials, and workmanship referred to herein are guaranteed to continue to perform as installed and to continue to provide effective corrosion control in accordance with the criteria elsewhere in these specifications and specifically indicating the inclusive dates of the guarantee period starting at the date of final acceptance of the correctly working system approved by the government and for a period of 1 year thereafter.

3.4. Operating and Maintenance Instructions.

- 3.4.1. Operating Instructions. The Contractor shall furnish to the Contracting Officer's representative twelve (12) complete copies of operating instructions detailing the step-by-step procedures required for system start-up and adjustment of the rectifier to achieve the criteria of protection. This shall include native system and component test data (data before system energization), test set up, test equipment diagrams showing voltmeter and reference cell connections, test locations, and a description of the procedure for measuring "on" and "off" potentials. Detailed steps shall show use of the equipment used in the training course and cover test and measurement of the cathodic protection systems for the gate leafs. The operation and maintenance manual shall be submitted to the Contracting Officer's representative for approval 30 days prior to the training course. Information on the equipment shall include the manufacturer's name, model number, service manual, parts list, and a brief description of all equipment and its basic operating features.
- 3.4.2. Maintenance Instructions. The Contractor shall furnish to the Contracting Officer's representative eight complete copies of maintenance instructions listing routine maintenance procedures, possible breakdowns and repairs, and trouble-shooting guides. The instructions shall include diagrams for the system as installed, instructions in making IR drop free tank-to-reference electrode measurements, and frequency of monitoring for each type measurement.

3.5. Training Course.

- 3.5.1. The Contractor shall conduct a training course for Fort Drum operating staff, as designated by the Contracting Officer's representative, on the operation and maintenance of the cathodic protection system. The training period shall consist of a total of 6 hours of training and shall start after the system is functionally complete and all contractor system commissioning testing is complete but prior to final acceptance testing by the Government Cathodic Protection System Expert. Course material, including testing data and records, shall be provided for a minimum of 5 Government attendees plus two copies for the Contracting Officer's representative. This course material shall be submitted to the Contracting Officer's representative for approval 30 days prior to the scheduled start of the training course. The training course shall include both classroom and field demonstrations of the procedure for measuring the NACE International protection criteria of minus 850 millivolts "instant-off" potentials as well as all monthly and annual maintenance and trouble shooting testing. The course manual shall provide a written documentation of these procedures in sufficient detail to enable an electrical technician who is knowledgeable in the use of digital meters and rectifier power supplies to perform the system weekly and monthly testing without additional instruction. This monthly and annual testing shall, as a minimum, meet the requirements of NACE International Recommended Practice RP0388 (latest edition). A new digital voltmeter (Fluke 123 Scope Meter multimeter or Extech Multi-Scope 381265 digital meter or similar and approved equal meter and an insulated cable (minimum 100 ft length) on a reel with a saturated copper-copper sulfate reference cell attached by a factory assembled waterproof connector shall be provided by the Contractor for these demonstrations. This equipment will become the property of the Government and shall be turned over to the Contracting Officer's representative upon completion of the training course.

Appendix E: Example Sensor Data

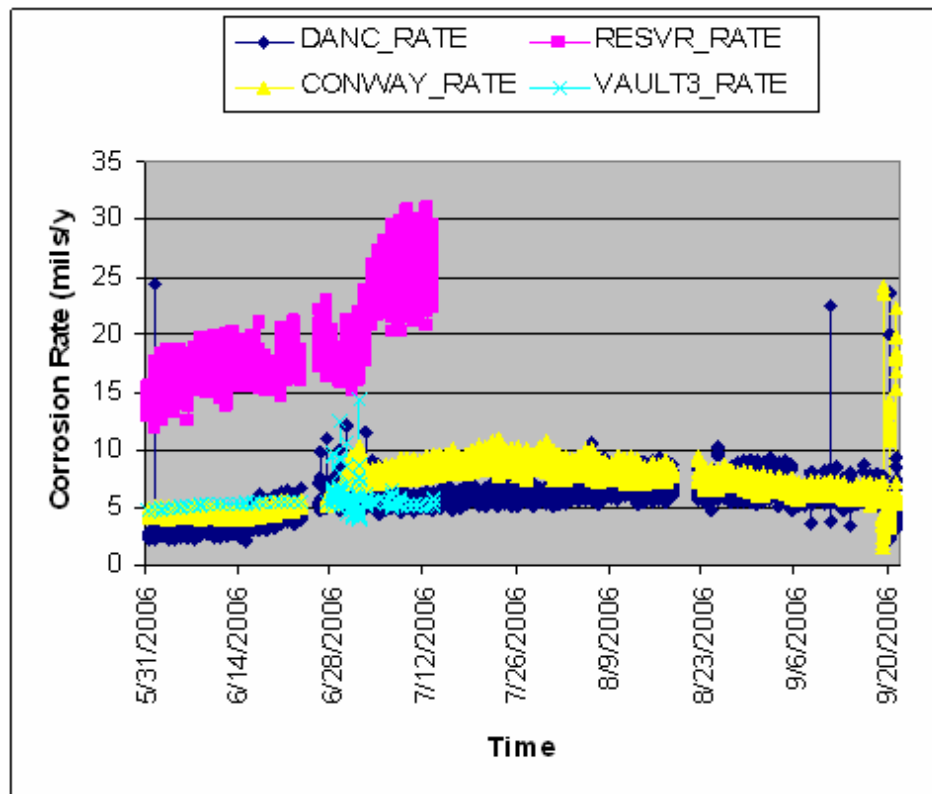


Figure E1. Sample instantaneous corrosion rate data from LPR sensors.

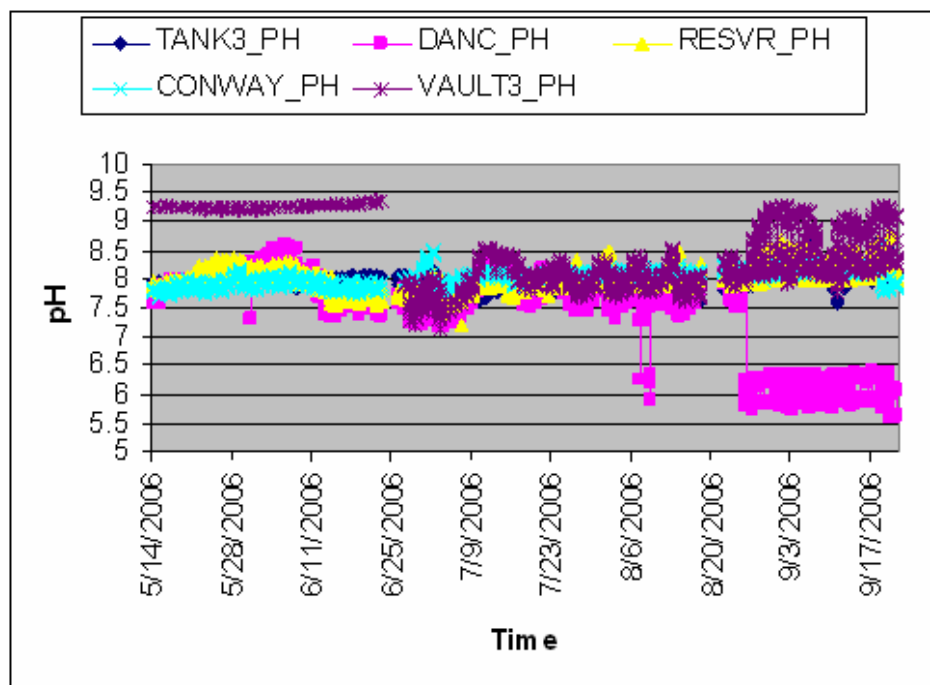


Figure E2. Sample pH data from PipeSondes.

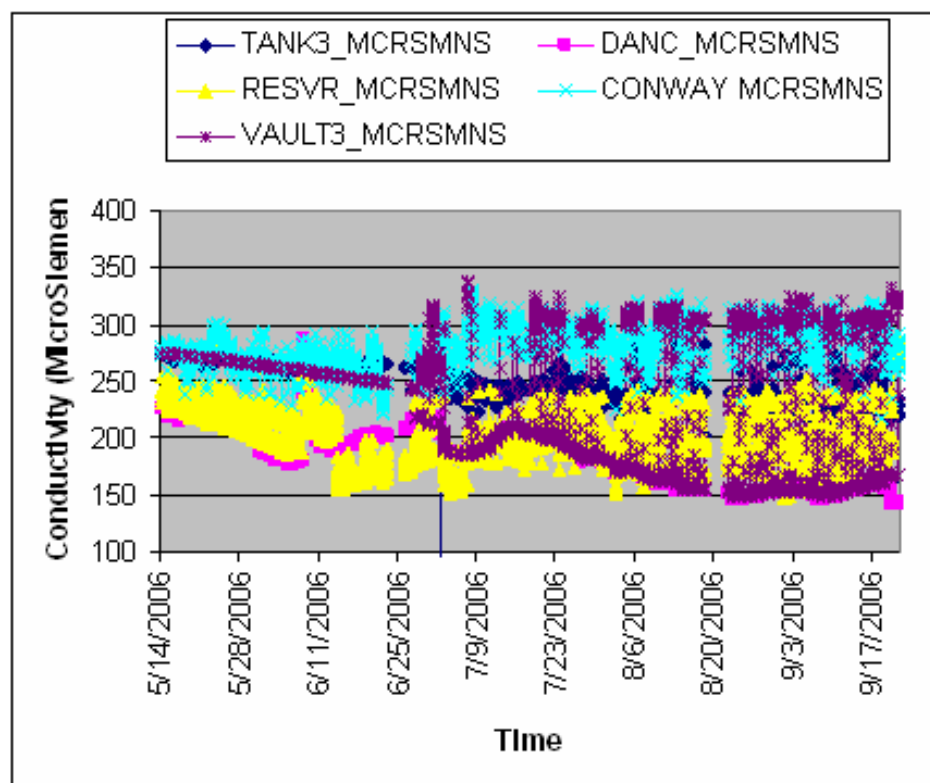


Figure E3. Sample conductivity data from PipeSondes.

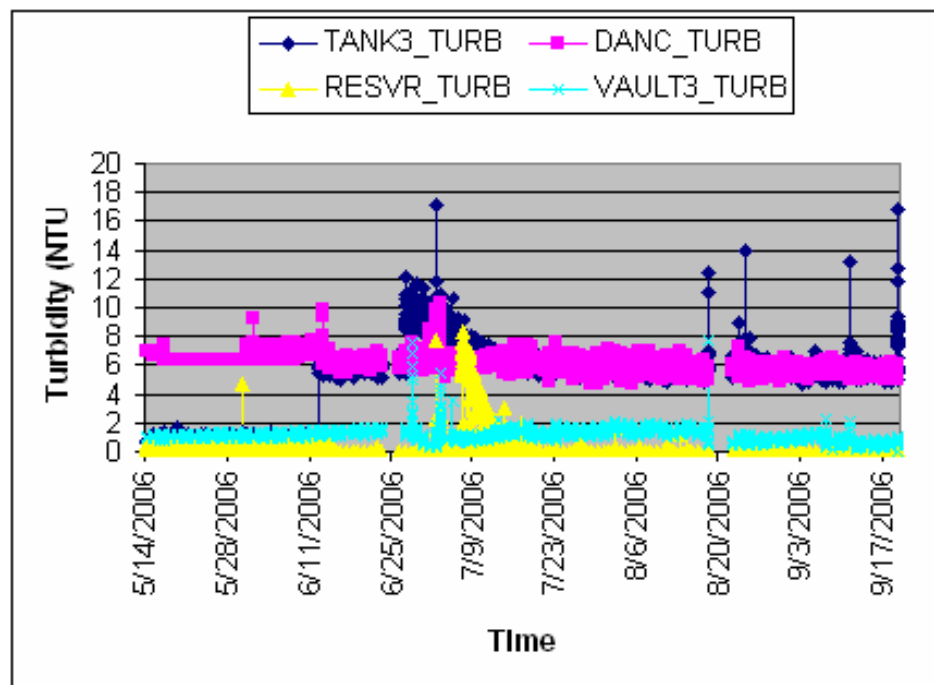


Figure E4. Sample turbidity data from Pipe Sondes

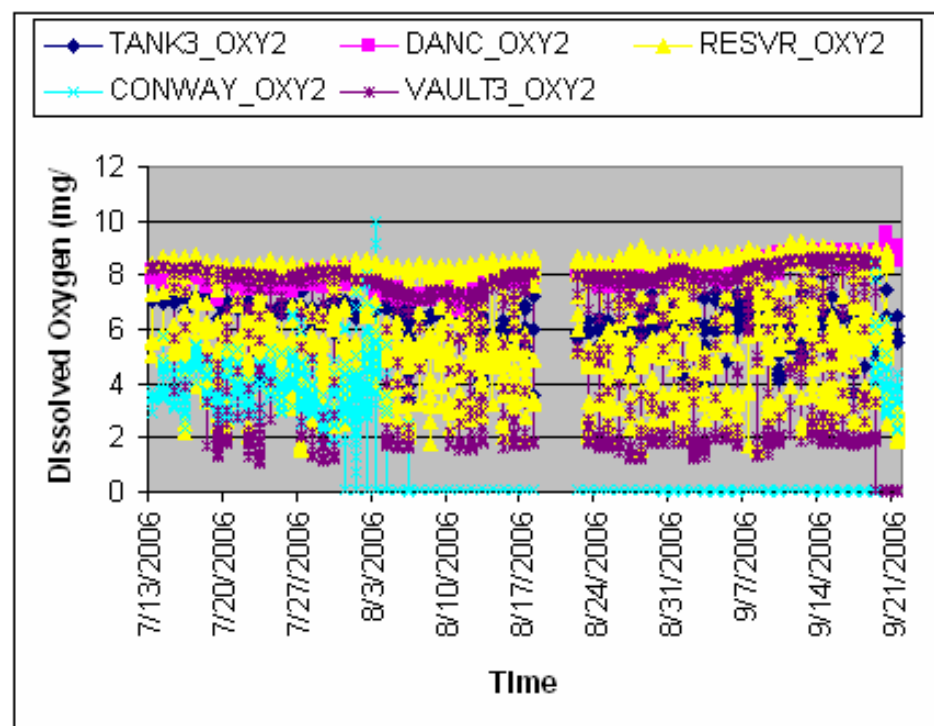


Figure E 5. Sample dissolved oxygen data from PipeSondes.

Appendix F: Updated Return on Investment (ROI) Projection

Method

OMB Circular A94, Appendix E, is used for this updated return on investment (ROI) projection.

Assumptions for revised ROI calculation

Alternative 1: baseline

Examination of the condition of the interior coating in Tank 3 during this project revealed numerous areas of coating damage that would be expected to undergo accelerated corrosion without the protection of a CP system. If this CP system had not been installed, Tank 3 would have required immediate re-coating at a cost of approximately \$1,000,000.

Data collected during this project showed that without CP, an unprotected tank wall would be expected to corrode at an average rate of 4.1 mils/yr (0.0041 inch). The thinnest area of the wall of Tank 3 in 1984 when the tank was installed was 6 mm, or 0.236 inch. We assume that we would replace the tank when 50% of the wall thickness, or 0.118 inch, remains. It will then take 28 years ($0.118/0.0041$) from the date of installation for corrosion to penetrate 50% of the tank wall. Thus, in 2012, or Year 6 of the analysis period, Tank 3 would require replacement at a cost of approximately \$1,500,000. Using the same logic, Tank 1 would require replacement in Year 28 at a cost of approximately \$2,000,000.

The tank maintenance and bottled water assumptions from the original ROI projection remain.

Alternative 2: ice-free CP system is implemented

Implementation of the ice-free CP systems on two elevated water storage tanks at a cost of \$1,000K is projected to extend the life of the tanks to the design life of 75 years; thus the tanks would not require replacement. The immediate re-coating of Tank 3's interior is not required; with the CP system in place it is estimated that the coating will last another 30 years. The

ice-free system is virtually maintenance-free; \$2,000 per year will be estimated for incidental repairs. The ice-free CP systems would require replacement in years 15 and 30, at an estimated cost of \$35,000 per tank.

Bottled water will not be required.

Comparing the two alternatives, the revised potential ROI for Alternative 2 is projected to be 11.75.

Return on Investment Ratio **11.75** Percent **1175%**

Net Present Value of Costs and Benefits/Savings 59,383 11,807,794 **11,748,410**

A Future Year	B Baseline Costs	C Baseline Benefits/Savings	D New System Costs	E New System Benefits/Savings	F Present Value of Costs	G Present Value of Savings	H Total Present Value
1	1,065,000		2,000	720,000	1,869	1,668,261	1,666,392
2	65,000		2,000	780,000	1,747	738,023	736,276
3	65,000		2,000	840,000	1,633	738,752	737,119
4	65,000		2,000	900,000	1,526	736,199	734,673
5	65,000		2,000	960,000	1,426	730,825	729,399
6	1,565,000		2,000	1,020,000	1,333	1,722,386	1,721,053
7	65,000		2,000	1,080,000	1,245	712,992	711,746
8	65,000		2,000	1,140,000	1,164	701,310	700,146
9	65,000		2,000	1,200,000	1,088	688,034	686,946
10	65,000		2,000		1,017	33,040	32,023
11	65,000		2,000	60,000	950	59,388	58,437
12	65,000		2,000	120,000	888	82,140	81,252
13	65,000		2,000	180,000	830	101,675	100,845
14	65,000		2,000	240,000	776	118,279	117,503
15	65,000		72,000	300,000	26,093	132,276	106,183
16	65,000		2,000	360,000	677	143,948	143,270
17	65,000		2,000	420,000	633	153,551	152,918
18	65,000		2,000	480,000	592	161,266	160,674
19	65,000		2,000	540,000	553	167,283	166,730
20	65,000		2,000	600,000	517	171,836	171,319
21	65,000		2,000	660,000	483	175,088	174,605
22	65,000		2,000	720,000	451	177,175	176,723
23	65,000		2,000	780,000	422	178,211	177,789
24	65,000		2,000	840,000	394	178,376	177,981
25	65,000		2,000	900,000	368	177,753	177,385
26	65,000		2,000	960,000	344	176,505	176,161
27	65,000		2,000	1,020,000	322	174,577	174,255
28	2,065,000		2,000	1,080,000	301	473,008	472,707
29	65,000		2,000	1,140,000	281	169,423	169,142
30	65,000		72,000	1,200,000	9,461	166,221	156,760

Year	Old System Costs				New System Costs			
	O&M Costs		Cost Avoidance		Tank Maintenance		Tank Replace	
	Maintenance	Tank Replace	Total	Bottled Water			Bottled Water	Total
1	1065000		1065000	720000		2000		2000
2	65000		65000	780000		2000		2000
3	65000		65000	840000		2000		2000
4	65000		65000	900000		2000		2000
5	65000		65000	960000		2000		2000
6	65000	1500000	1565000	1020000		2000		2000
7	65000		65000	1080000		2000		2000
8	65000		65000	1140000		2000		2000
9	65000		65000	1200000		2000		2000
10	65000		65000	0	0	2000		2000
11	65000		65000	80000		2000		2000
12	65000		65000	120000		2000		2000
13	65000		65000	180000		2000		2000
14	65000		65000	240000		2000		2000
15	65000		65000	300000		2000	70000	72000
16	65000		65000	360000		2000		2000
17	65000		65000	420000		2000		2000
18	65000		65000	480000		2000		2000
19	65000		65000	540000		2000		2000
20	65000		65000	600000		2000		2000
21	65000		65000	660000		2000		2000
22	65000		65000	720000		2000		2000
23	65000		65000	780000		2000		2000
24	65000		65000	840000		2000		2000
25	65000		65000	900000		2000		2000
26	65000		65000	960000		2000		2000
27	65000		65000	1020000		2000		2000
28	65000	2000000	2065000	1080000		2000		2000
29	65000		65000	1140000		2000		2000
30	65000		65000	1200000		2000	70000	72000

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14. ABSTRACT The anodes for conventional cathodic protection (CP) systems used inside water storage tanks are often damaged by ice during cold weather. The CP system described in this report uses ceramic-coated wire anodes and a floating support system to keep the anodes submerged beneath surface ice in the tank. Demonstration systems were installed in two elevated water storage tanks at Fort Drum, NY. System performance is monitored using the existing supervisory control and data acquisition (SCADA) system at Fort Drum. This report describes the ice-free CP system design, implementation, and performance during Fiscal Year 2005.					
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